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FOREIGN SHIPBUILDING SUBSIDIES

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SUBCOMMITTEE ON MERCHANT MARINE

OF THE

COMMITTEE ON MERCHANT MARINE AND FISHERIES HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRD CONGRESS

FIRST SESSION

ON

THE PROBLEM FACING U.S. SHIPPING INTERESTS IN THE WORLD MARKET DUE TO DIRECT FOREIGN GOVERNMENT SUBSIDIES AND WHAT MARITIME REFORMS ARE NEEDED TO ALLEVIATE THIS PROBLEM

JUNE 30, 1993

Serial No. 103-36

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CONTENTS

FOREIGN SHIPBUILDING SUBSIDIES

WEDNESDAY, JUNE 30, 1993

House of Representatives,
Subcommittee on Merchant Marine,
Committee on Merchant Marine and Fisheries,
Washington, DC.

The Subcommittee met, pursuant to call, at 2:15 p.m., in room 1334, Longworth House Office Building, Hon. William O. Lipinski (Chairman of the Subcommittee on Merchant Marine) presiding.

Present: Representatives Lipinski, Pickett, Taylor, Andrews, and Schenk.

Staff Present: Keith Lesnick, Staff Director; Sharon K. Brooks, Counsel; David Honness, Professional Staff; Randy Morris, Subcommittee Clerk; Jim Caponiti, MarAd Detailee; Fred Zeytoonjian, Staff Aide; Hugh N. Johnston, Minority Counsel; Shelby Mertes, Staff Aide; Joan M. Bondareff, Senior Counsel; John Cullather, Professional Staff; Carl W. Bentzel, Counsel; Sue Waldron, Press Assistant; Cynthia M. Wilkinson, Minority Chief Counsel; Kip Robinson, Minority Counsel; and Margherita Woods, Staff Assistant.

Mr. Lipinski. Good afternoon, everyone. I apologize for being late, but we had a series of votes on the Floor. And on top of that, I thought we were going to have another one very quickly. But that was not the case. I think we will have one in a fairly short amount of time. But I want to start the hearing now.

STATEMENT OF THE HON. WILLIAM O. LIPINSKI, A U.S. REPRESENTATIVE FROM ILLINOIS, AND CHAIRMAN, SUBCOMMITTEE ON MERCHANT MARINE

Mr. Lipinski. This is yet another in a series of hearings on maritime reform. We will hear from the shipbuilding industry as part of our maritime revitalization efforts.

As many of you know, a major problem facing U.S. shipping interests and their place in the world market is the disparity between U.S. and foreign shipbuilding costs. Foreign shipyards are able to undercut American prices because they receive direct government subsidies. U.S. shipyards do not. It is as simple as that.

This country stopped our subsidy program over a decade ago, and we have sought unsuccessfully to convince the other nations of the world to follow suit. It is time to level the playing field with our competition and get back in the game.

If we are to revitalize this important industry and our infrastructure, we must address the financial and technological needs of the U.S. shipyards, and we must address the obstacle of foreign subsidies.

The subcommittee will hear testimony today from Mr. Robert O'Neill, Vice President of the American Waterways Shipyard Conference; and Mr. John Stocker, President of the Shipyard Council of America.

John, you have been here on a number of occasions; and we welcome you once again.

I would now like to recognize our Ranking Minority Member, Mr. Bateman.

Unfortunately, because of the situation on the Floor and the number of votes that we had and the strong possibility we are going to have another vote very shortly, he is probably tied up over there with some issues. I am sure that he will be here as soon as he possibly can make it.

So the Chair will now recognize our good friend, Mr. Taylor, for his opening statement, if he has any.

STATEMENT OF THE HON. GENE TAYLOR, A U.S. REPRESENTATIVE FROM MISSISSIPPI

Mr. Taylor. Only to thank you for holding this hearing. And since we probably will have a series of votes, Mr. Chairman, I will yield my time back.

Mr. Lipinski. Thank you very much.

[The statement of Mr. Fields follows:]

Statement of Hon. Jack Fields, a U.S. Representative from Texas, and Ranking Minority Member, Committee on Merchant Marine and Fisheries

Mr. Chairman, today's hearing is intended to give representatives of the American shipbuilding industry the opportunity to address issues associated with foreign shipbuilding subsidies as well as the legislative effort to craft a new maritime policy to reform the operating subsidy program.

As Members of the Subcommittee will recall, in the last Congress this Committee addressed foreign shipbuilding subsidy issues in the context of Congressman Gibbons' bill (H.R. 2056). We approved that bill and it was subsequently passed by the House of Representatives. The bill failed in the Senate at the end of the Session.

This Congress, Mr. Gibbons has introduced H.R. 1402, a modified version of his earlier legislation. The new bill was referred exclusively to the House Ways and Means Committee because it does not include a number of provisions that were in the earlier bill related to matters within our Committee's jurisdiction.

Even though H.R. 1402 is not pending before our Committee, it is appropriate to hold this oversight hearing to hear from the one important sector of our maritime industry—the shipbuilders.

As a strong proponent of revitalizing our domestic maritime industry, I strongly support, and have cosponsored, a number of bills designed to promote the U.S. merchant marine. I must say, however, that I have some reservations about H.R. 1402. While it is critical for the long term future of our shipbuilding industry to solve the problems presented by foreign subsidies, we must not create additional problems for our domestic ports and operators.

In addition to addressing the foreign subsidy problem, it is timely for the Committee to receive testimony from the shipbuilding sector on matters related to other legislation our Committee is considering in the overall effort to revitalize our maritime industry. Therefore, any comments that the witnesses may have with regard to H.R. 2151, the Maritime Security and Competitiveness Act of 1993, would be appropriate and helpful.

Thank you, Mr. Chairman. I look forward to a good hearing this afternoon.

Mr. Lipinski. Well, we have a divided opinion here on my staff. I said who goes first, and one said Mr. O'Neill; the other one said it doesn't make any difference. So we are going to leave it up to you, gentlemen, whoever wants to go first.

STATEMENT OF ROBERT F. O'NEILL, VICE PRESIDENT, AMERICAN WATERWAYS SHIPYARD CONFERENCE

Mr. O'Neill. Thank you. I will grab the ball.

Mr. Chairman and Members of the Merchant Marine Subcommittee, I am Robert O'Neill, Vice President of the American Waterways Operators and Director of the American Waterways Shipyard Conference. I want to thank you for the opportunity to appear here before you today along with Mr. Stocker.

In addition, I want to commend you, Mr. Chairman, for your active interests and determination on behalf of the U.S. maritime industry. Today's hearing and the legislation reported out this morning are more examples of your leadership during these watershed times.

The American Waterways Shipyard Conference is the national trade association representing second tier, small- and medium-sized shipyards. Its mission is to participate actively on behalf of second tier shipyards in the legislative and regulatory processes and to provide education and information both to its members and to the public. A list of AWSC members is attached to my written statement.

AWSC is a conference of the American Waterways Operators, the national trade association for the inland and coastal tug and barge industry.

AWSC members build and repair towboats and barges, offshore service vessels, fish and fish processing vessels, passenger vessels, oceanographic research vessels, as well as dredging vessels for the Army Corps of Engineers, U.S. Navy, and Coast Guard vessels and vessels used by State and local governments for port management and safety.

Second tier shipyards are a key component of the U.S. shipbuilding and ship repair capability. Second tier shipyards are those shipyards that build and/or repair steel aluminum vessels upwards to 600 feet in length.

A second tier shipyard employees anywhere from 15 to 3400 workers and operates on the inland river system, the Gulf Coast, the Pacific Northwest, the Great Lakes, and the East Coast.

Historically, second tier shipyards have been small, independent businesses, owned and operated by individuals and families and are managed by a relatively small staff. They are fiercely competitive and innovative.

In fact, a few AWSC members have been successful in the international marketplaces and build vessels for export. Despite unfair subsidy practices by foreign countries, the second tier shipyards in operation today, while they still face many difficulties, have survived a severe industry downturn during the mid and late 1980's and have emerged leaner and better able to compete in today's tough market. Indeed, we see them rising to a new ascendancy by the end of the century because of their energy, productivity, and competitiveness.

We believe that America must remain a maritime nation. There have been countless speeches and pronouncements to this effect over the years. This has been even more pronounced in the consid-

eration of maritime reform legislation and related issues in the 102nd Congress and now in this Congress.

As we debate the steps necessary to maintain some semblance of a maritime nation, one that matches the Nation's needs, let us remember that both the industrial strength and the national security of the United States depends, in significant measure, on a strong and responsive shipbuilding industry.

America must have the ability to design, build, and repair all types and sizes of vessels, ranging from river tugs and barges to oceangoing cargo vessels and large military vessels. We have arrived at a time when decisive action by the administration and the Congress is needed to reach and maintain this important goal.

During our Nation's history, we have equipped ourselves to fight wars, cure diseases, and fly to the moon. All these challenges have been met for the purpose of protecting the common good and enhancing the quality of life. By revitalizing the U.S. maritime industry, and the shipyards that service it, we will again remain faithful to our predecessors by doing the right thing for America.

At this point, I would like to offer some general comments and observations about what should be done to address the problems we face.

In the long-term, the Congress must act on measures that will increase our competitive strength. I emphasize this element because the future of U.S. shipyards will be determined primarily on whether or not they are capable of building and repairing vessels in a cost-efficient, high quality, and on-time fashion. This holds true for all other industries.

Therefore, the Congress and the administration must put in place measures that will equip U.S. shipyards with the tools to design, build, and successfully market vessels throughout the world. In support of this goal, I offer a few suggestions:

One, Federal agencies such as the Department of Commerce, the Maritime Administration, and the Export-Import Bank must be energized with the mission of actively promoting the U.S. shipyard industry. If reorganization is necessary to make agencies and departments to perform, than so be it. U.S. shipyards must have a strong advocate to promote U.S.-built products.

Number two, realistic efforts to unify U.S. and international building standards must be brought to a successful conclusion. Efforts by the Shipbuilders Council of America and the Coast Guard have been particularly beneficial. I hasten to point out that the same effort should be undertaken for small- and medium-sized vessels and equipment.

Three, continued action and funding of the Sealift modernization program is a must. While helping to fulfill the paramount goal of bolstering our U.S. security, a vigorous program will also provide opportunities for second tier shipyards.

Four, AWSC supports the shipbuilding technology program sponsored by the Advanced Research Projects Agency. This effort is part of the overall technology reinvestment program aimed at helping defense-related industries make a transition to civilian-oriented products. This program shows signs of promise, and it deserves the active support of the administration, Congress, and industry.

AWSC believes that joint government industry cost sharing programs can be of benefit if they are well organized and focused. To this end, AWSC will submit a proposal to ARPA that includes joint industry/government funding of a market study to identify international commercial market opportunities, well as generate up to five innovative vessel designs and manufacturing systems to produce those vessels in a cost-efficient fashion.

Number five, and in conclusion, some of our foreign competitors enjoy subsidies and other promotional advantages from their respective governments. This has distorted market conditions. The trade negotiations held under the auspices of OECD have failed to produce an agreement and a process to eliminate or reduce these subsidies. We are grateful to Representative Gibbons for introducing H.R. 1402 and for forcing the Congress and the administration to focus on this problem.

The solutions to our problems are achievable. Are the problems serious? Yes, of course. Are subsidies part of the problem? Yes. But let us not deceive ourselves that it is the only part of the problem. The answer lies in timely and sustained efforts in public and private sectors united in a new, dedicated, and vigorous partnership.

As Americans, we are united in our desire to do the right thing for our country. Every measure we take as public officials and interested citizens is guided by this principle. The challenge is tall, but we have met many fearsome challenges in the past.

Mr. Chairman, once again I want to thank you for the invitation to appear today as well as the efforts by you and Chairman Studds on behalf of the U.S. maritime industry and the shipyards that support it.

Mr. LIPINSKI. Thank you, Mr. O'Neill. We also have a copy here—and I will turn in for the record without objection—of the American Waterways Shipyards Conference to members that you have been good enough to supply us with.

Mr. O'NEILL. Thank you very much.

[The statement of Mr. O'Neill may be found at end of hearing.]

Mr. LIPINSKI. The Chair will now recognize Mr. Stocker.

STATEMENT OF JOHN STOCKER, PRESIDENT, SHIPBUILDERS COUNCIL OF AMERICA

Mr. STOCKER. Mr. Chairman, thank you very much.

My name is John J. Stocker, and I am President of the Shipbuilders Council of America, which is the national trade association that represents private American shipyards, marine equipment suppliers and naval architects.

I should add that our membership tends to be in the larger shipyards as compared to the membership that Mr. O'Neill's organization represents.

We have attached to our written testimony a list of member companies of the Shipbuilders Council for inclusion in the record.

We appreciate the opportunity to express our views to you today, Mr. Chairman, on H.R. 2151, H.R. 2152, H.R. 1402, S. 990, and legislation that was introduced last night and marked up this morning, H.R. 2547, a piece of legislation that is directed toward assisting American shipyards in gaining market access.

We want to thank you, Mr. Chairman and the members of the subcommittee, and the full committee, for their leadership in dealing with issues concerning maritime reform and in assisting the U.S. shipbuilding and ship repair industries in attaining a competitive position in the world marketplace.

The members of the committee understand that it has been four years since the Shipbuilders Council initially filed its Section 301 petition with the U.S. Trade Representative and over a year since the international trade negotiations that were launched responding to that petition have collapsed.

During that period of time, our trading partners have not ended their subsidy practices, and the situation in American shipyards has gotten steadily worse. With the significant downsizing of the naval fleet during the remainder of the 1990's, the U.S. shipbuilding industry is facing massive layoffs and yard closures. It is our estimate that by 1998, there will be only one or two major American shipyards left that can build big, oceangoing ships. We will be down to about 28,000 employees by comparison to the current situation of roughly 100,000, unless we can somehow gain access to commercial ship construction contracts in the next couple of years.

Obviously, Mr. Chairman, American shipyards, we believe, are an integral part of the U.S. economic fabric; and we think that for both reasons of economic policy as well as national security policy, that programs should be put into place to support American shipyards. We should also continue to focus on the issue of the distortions that currently exist in the international market and take steps to remedy those distortions.

As you pointed out, Mr. Chairman, the industry has gone without subsidy since 1981 when the U.S. Government unilaterally ended the CDS program for U.S.-flag ships built in U.S. yards.

As we have pointed out on a number of occasions, the timing could not have been worse for that decision because as the international shipbuilding market went into depression, we ended our subsidies and our colleagues around the world increased theirs. As a result, the possibility of any commercial work coming to the United States was made moot.

In fact, it was recognized that the existence of these practices were becoming so distortive of the marketplace that early in the 1980's the Organization for Economic Cooperation and Development, known as the OECD, recognized the basic anticompetitive nature of these subsidy practices; and they, in fact, signed a document in which they agreed not to introduce any new measures and to gradually eliminate the ones they already had. Unfortunately, that document failed to come into play because they failed to put an enforcement mechanism into place.

Negotiations were launched in 1989 that led to a draft agreement which was tabled in December of 1991. The U.S. shipbuilding industry immediately supported this draft agreement and indicated to the U.S. Trade Representative that we did. However, in April of 1992 the European Community, Japan, and South Korea, caused the talks to collapse.

We believe the reason they undermined the talks was because of the fact that they were unwilling to end their practices. We, frankly, Mr. Chairman, had no cards to play during the negotiating proc-

ess; and as a result, they did not feel compelled to meet our expectations of ending their practices. These practices continued since April of 1992.

My statement and our accompanying study on international shipbuilding make it very clear that during the time period in the past 16 months or so, subsidy practices have continued and have continued to support contracts that have been awarded to foreign shipyards.

What we have to conclude, Mr. Chairman, is there are trading partners that are going to hold on very tightly to their shipbuilding subsidy practices unless they have a strong enough incentive to discontinue them.

Before I begin my comments on the legislation that has recently been introduced by the Merchant Marine Committee leadership, I should comment on the legislative efforts that are being undertaken to solve the problem of foreign subsidy practices.

I agree with Mr. O'Neill that solving the foreign subsidy question on its own is not sufficient to create positive market conditions for U.S. shipyards. But, getting control of foreign government distortions of the marketplace must be achieved, because the industry recognizes the limitations on the Treasury in the inability to construct the Federal funding programs of the past.

The goal of H.R. 1402, the Shipbuilding Trade Reform Act of 1993, commonly referred to as the Gibbons bill, is intended to provide an incentive to foreign countries that ties discontinuation of shipbuilding subsidy and shipbuilding practices to U.S. market access.

The statement that I have provided indicates the similarities and the differences between H.R. 1402 and the bill that was passed last year by the House, H.R. 2056, that unfortunately stalled in the Senate.

S. 990 is a similar bill to H.R. 1402.

Mr. Chairman, we believe that one or the other pieces of these legislation is absolutely vital in order to achieve success in the negotiating process. In other words, without leverage, our trade negotiators cannot achieve success in the negotiating process. We expect a statement out of the administration tomorrow morning in regard to their point of view and regard to H.R. 1402.

Let me turn to the maritime reform legislation that this committee has been working aggressively on over the past few weeks. We, first of all, want to congratulate you on the efforts that you have been making in attempting to deal with the problems facing U.S. flag operators as well as U.S. shipyards.

H.R. 2151, we understand that the committee is attempting to modernize the government support programs for U.S.-flag operators.

We are concerned, however, about efforts that may lead to inadvertent U.S. market access to foreign subsidizers. While we support the language in Section 403(b)(2) that prohibits the U.S.-flag carrier from building in a foreign subsidized shipyard, we don't believe that the current cutoff date of May 19th will be effective in closing off access to the marketplace. We believe there are contracts currently in place that are prior to the May 19th deadline.

Secondly, the committee needs to be aware that we are concerned about language in 403(b)(4)(B) that permits secondhand vessels less than 10 years old to enter U.S. flag. We are a little concerned about the potential for a circumvention of the ban on subsidized foreign ships coming into the marketplace.

In regard to H.R. 2152, which was a measure to modernize the CCF program, we support the bill; and we pledge our efforts to the committee to work with you to obtain passage of the legislation.

Finally, Mr. Chairman, there has been considerable discussion of late of more directed and specific programs to assist U.S. shipyards in gaining market access to the future global market. We want to thank the committee Members and staff for the work that has gone into the legislation that was introduced yesterday and marked up this morning.

We believe the legislation will address many of the concerns we have about improving our competitiveness. Mr. O'Neill is quite correct that the number one priority for both the second tier and the larger shipyards is improving our competitiveness so that once the market access is achieved, we can maintain market share. We also believe that the efforts that were undertaken this morning by the committee can be made to fit within an overall U.S. trade policy that searches for an international solution of the problems of foreign government distortions of the marketplace.

While it is difficult to know at present if the combination of research and development efforts, Title XI restructuring, series production support, and chartering of double-hull tankers by the Defense Department is the right mix, it is in our view that all options must be explored. We are not certain which button needs to be pushed in order to create success.

Mr. Chairman, in closing, our own unsubsidized industry is on the brink of destruction. Our yards cannot fight foreign governments. Furthermore, unless our government acts quickly, it will not only be American shipyards and American shipyard workers who will be affected but also the country's steel mills, marine equipment manufacturing plants, and more than 1,000 other U.S. shipyard supplier industries. By 1998, we run the risk that another 180,000 Americans will be on the unemployment lines unless something is done now to enable American shipyards to reenter the commercial market.

Thank you very much.

Mr. Lipinski. Thank you very much, Mr. Stocker.

And I realize that you moved around a little bit in your testimony, and so that we have your full testimony, without objection, I would like to accept your testimony in its totality here.

We don't have any objection, so we will do that.

[The statement of Mr. Stocker may be found at end of hearing.]

Mr. Lipinski. We will also place in the record—you supplied us with the supporters of the Shipbuilding Trade Reform Act of 1993—your organizations and the members of the Shipbuilders Council of America. We will also include that in the record.

I, first of all, would like to start off the questioning this afternoon with a question for Mr. O'Neill.

Mr. O'Neill, you mentioned that many of the shipyards in your conference are able to compete in the world market today even though many foreign shipyards are receiving subsidies.

What kind of market share do they have today? And what kind of share do you think they are capable of if subsidies were eliminated worldwide?

Mr. O'NEILL. Basically, there are several yards, several companies, in our organization that have been successful in the international marketplace. They, by no means, hold a major share; but they hold oh, I would say, anywhere from 5 to a 10 percent share in some of the types of markets that they are involved in, such as fishing vessels, let's say small military patrol boats, crew boats and things of that—vessels of that nature.

I happen to think that they are capable of occupying still an even larger portion of those markets if the playing field were brought down to an absolutely fair and level situation.

So, at the risk of sounding like a cheerleader, I would think that our yards could move up to 25, 30 percent of many of those types of market niches, maybe more.

Mr. LIPINSKI. Do you have any figures available today on what countries have what market shares at the present time?

Mr. O'NEILL. I don't have that information at my fingertips now, Congressman; but I would be glad to get it for you. And if I may I would request permission to submit that in writing for the committee's consideration.

Mr. LIPINSKI. We would appreciate it very much. We certainly could use that.

Mr. LIPINSKI. Mr. Stocker, it is the subcommittee's understanding that several of your members don't believe that they will pursue contracts in the container vessel market for the foreseeable future and they will, instead, concentrate on the growing tanker market.

Do you believe this is a fair assessment of the situation?

Mr. STOCKER. Mr. Chairman, a number of our companies are looking at specific market sectors that they will pursue. I think it is up to each individual company to determine which market sector offers them the best potential for being competitive.

We have shipyards that are looking at the O&G tanker market. We have companies that are looking at the OCC market. While some companies have indicated that container ships are something that they may not necessarily move to aggressively, I would hesitate to say that there is some particular company within the industry that would not seek to enter the container ship market.

I think it would be a mistake for us to try to predetermine which market segments would be most appropriate for our industry since each company knows best what its strengths and weaknesses are.

In response to your question to Mr. O'Neill, just a rough order of magnitude, a market share of the Japanese control 40 percent of the market, and the Koreans control 23 percent, the European Community has about 20 percent of the market share. I will work with Mr. O'Neill to provide you definitive answers in detail on what the total breakdown is by individual country.

Mr. LIPINSKI. Thank you, Mr. Stocker.

The Chair now recognizes Mr. Taylor?

Mr. TAYLOR. Thank you, Mr. Chairman.

I want to open this up to both of you gentlemen.

Mr. O'Neill, with respect to your organization, it is my understanding that your organization, in the past few months, has been actively receiving orders for either the building or the conversion of double-hull vessels, in the range that you determined, 600 feet on down.

Mr. Stocker's organization, on the other hand, has shown a bit of reluctance.

I am just curious. It is my feeling that somehow the oil companies or those people in the marine transportation business might be thinking that there is going to be some backsliding in the international area as far as ships coming in internationally to our shores. But we are going to stick to our guns on the Jones Act.

I would like to hear your opinion on that. And I would also like to hear your opinion if you would like to see this committee speed up the provisions and the implementation of OP 90 as far as those people using single-hull tankers before they are retired or sent someplace else in this world.

Mr. O'NEILL. I have not perceived, Congressman, any deliberate backsliding on the international front versus the Jones Act.

Although, as you point out, that may very well be a dynamic that is at play here. In terms of our advocating any kind of stepped up compliance or tightening of the deadlines for OP 90, that is a very critical question.

I don't want to get out too far in front of my membership here on this question, but I think that would be something to consider. But I don't want to take that question on right now. It is very delicate in terms of within our organization. We also have carrier members as well as shipyard members. So in light of that, I don't think I can give you a direct comment on that.

Mr. TAYLOR. Can I ask you to poll your membership?

Mr. O'NEILL. Sir, I would be glad to do that.

Mr. STOCKER. Mr. Taylor, let me respond to the questions that you have raised.

First of all, I think it is true that our trading partners recognize that the United States' position on the Jones Act is an extremely tough one and one that we are not likely to back off on in the course of the coming years.

Do they believe that we are not going to approach the international problem with any ferocity or intent of purpose? I doubt it very much. I think they recognize that this is an issue that is receiving broader attention before the Congress and the administration and that certainly it has to be resolved.

Mr. O'Neill's members are fortunate in the sense, too, that in their market segment, which tends to be in the smaller ship scale, the existence of subsidy practices, while real, are not as distorted as they are on the larger ships. I don't want to minimize the impact on them. We have found in our analysis that it is usually on the high value end of the market, the complicated ships, the passenger ships, the O&G tankers, and so on, where we have seen the greatest level of government intervention because they are big ticket items, and they are also relatively more labor intensive than the smaller bulk carrier or the smaller tanker.

So that explains part of the reason why some of the smaller shipyards have been successful at being able to penetrate the global market. Some of those companies are members of our organization as well.

Companies like Bender, for example, have been very successful in being able to sell shrimpers to Kuwait and drill barges to Venezuela and patrol boats to Colombia. So efforts are being undertaken by companies and even in the big yards. I don't want to leave you with the impression that we are sitting back waiting for somebody to solve the problem. Big yards are out talking to the marketplace, talking to the owners, trying to get a fix on where the demands are and so on.

It is pretty clear to me that in that particular area, we are going to see a continued high level of activity no matter what happens.

On the subject of OP 90, we would fully endorse an acceleration of the phaseout schedule. Frankly, the position adopted by the International Maritime Organization is more aggressive than the position that has been adopted by the U.S. Government.

In our own view, the question of unsafe ships is one that is gaining widespread concern and support for dealing with that issue. Internationally, we found that in our discussions with owners and builders around the world, there is a real concern about taking unsafe ships off the marketplace.

So we would welcome some attempts to try to bring some of those issues to resolution in the U.S.

Mr. LIPINSKI. I am going to interrupt you at the present time. We are going to go over and vote. We will return as quickly as possible, and the Chair will, once again, at that time, recognize Mr. Taylor.

[Recess]

Mr. LIPINSKI. Well, we are back. For how long, who knows? In light of that, I am going to recognize Ms. Schenk for her questions.

STATEMENT OF THE HON. LYNN SCHENK, A U.S. REPRESENTATIVE FROM CALIFORNIA

Ms. SCHENK. Thank you, Mr. Chairman. And I do have an opening statement, and I ask unanimous consent to submit it for the record.

Mr. LIPINSKI. Well, if you won't object, I won't object. So ordered.

[The statement of Ms. Schenk follows:]

STATEMENT OF HON. LYNN SCHENK, A U.S. REPRESENTATIVE FROM CALIFORNIA

Thank you, Mr. Chairman, and I commend you for holding this important and timely hearing.

Since Federal shipbuilding subsidies were eliminated early in the Reagan Administration, we have witnessed the loss of over 40 U.S. shipyards and along with them thousands of good jobs for American workers. It is time to stop the hemorrhaging and reestablish the U.S. as an internationally competitive shipbuilding nation.

U.S. shipbuilders cannot compete without our help in an internationally market controlled by countries that subsidize their shipbuilding industry. Our industry is an endangered species and the free market does not provide a restoration plan. We must act swiftly before American shipbuilding is solely a subject for museums.

Mr. Chairman, the bills we are discussing today are important steps in the right direction. I am proud to be a cosponsor of H.R. 2151, and I am happy that we have a chance today to discuss ways to strengthen the Federal Government's efforts to preserve a vital American industry.

I want to welcome Mr. Stocker and Mr. O'Neill and express my appreciation to you for taking time to be with us today. I look forward to hearing your views.

Again, thank you, Mr. Chairman.

Ms. SCHENK. I guess we don't have enough for the party like we did before.

Mr. Stocker, I have a couple of questions for you. I understand that you indicated that you believe American shipyards need to build 30 to 50 commercial ships a year in order to become internationally competitive. Do you believe that the support proposed in H.R. 2151 is adequate to achieve that level of production?

Mr. STOCKER. The language, Congresswoman, in 2151 which is directed toward creating the conditions for modernization for U.S. ship operators will not necessarily lead to construction of ships in U.S. shipyards. We think it is helpful that the language that specifically inhibits U.S. ship operators from buying from foreign ship builders is helpful in maintaining the U.S. trade stance toward these subsidy practices. But those measures in and of themselves will not lead to construction of ships in the United States.

Ms. SCHENK. Well, thank you. Mr. Stocker, if we have to compete with subsidized foreign ship builders, would the SCA support, as a complement to 2151, a program that assures that a fair share of U.S. imports are reserved for U.S.-built, U.S.-owned, U.S.-operated ships?

Mr. STOCKER. We are prepared to accept any measures that would help us gain market access and if it appears to us that our trading partners absolutely refuse a cessation of their subsidy practice, all bets are off and what we have is a full-fledged trade war with Asia and Europe. We cannot sacrifice our shipyards to other countries unless we are prepared to protect ourselves. We think it is premature to close off any options that we might want to consider.

Ms. SCHENK. Do you think that a short-term program of cargo reservation, say five to 10 years, would provide sufficient protection to allow the American shipbuilding industry to achieve international production levels and then be able to compete in the international shipbuilding market?

Mr. STOCKER. That is a question we are taking a look at right now, and we will be back to the committee with a response to that at a later date.

Ms. SCHENK. Thank you, very much. That is all that I have.

I yield back the balance of my time.

Mr. LIPINSKI. Thank you very much. I have some questions that I may submit to you and I am sure that you will answer for the record.

I want to say I apologize to you for the delay in starting this hearing, for the interruptions, for the lack of attendance. I personally apologize for this, but it is just one of those things. We have a very controversial piece of legislation on the Floor. I stayed over there to be guaranteed that we would have at least 40 minutes to finish our agenda over here. I arrived back over here and we have another vote. How that came to pass, I don't know. But I appreciate your patience here.

If we feel that it is necessary for you to come back at some time, we will certainly schedule much earlier in the morning so that we

don't have any conflicts. Thank you very much. Have a wonderful day.

Mr. STOCKER. Thank you, Mr. Chairman.

Mr. O'NEILL. Thank you, Mr. Chairman.

[Whereupon, at 3:14 p.m., the Subcommittee was adjourned; and the following was submitted for the record:]

AMERICAN WATERWAYS SHIPYARD CONFERENCE
1600 Wilson Boulevard, Suite 1000, Arlington, Virginia 22209 Phone: (703) 841-9300 Fax: (703) 841-0389

Testimony By
Robert F. O'Neill, Vice President
American Waterways Shipyard Conference

Before

The Subcommittee on Merchant Marine of the
House Merchant Marine and Fisheries Committee

on

Maritime Reform/Foreign Shipbuilding Subsidies

Room 1334
Longworth House Office Building
1:30 p.m.
June 30, 1993

Mr. Chairman and Members of the Merchant Marine Subcommittee, I am Robert O'Neill, Vice President of the American Waterways Operators and Director of the American Waterways Shipyard Conference (AWSC). I want to thank you for the opportunity to appear before you today and to serve on this distinguished panel representing the U.S. shipbuilding and ship repair industries. In addition, I want to commend you, Mr. Chairman, for your active interest and determination on behalf of the U.S. maritime industry. Today's hearing is yet another example of your leadership during these watershed times.

The American Waterways Shipyard Conference is the national trade association representing second-tier -- small and medium size -- shipyards. Its mission is to participate actively on behalf of second tier shipyards in the legislative and regulatory processes and to provide education and information both to its members and to the public. A list of AWSC members is attached to my written statement. AWSC is a conference of the American Waterways Operators (AWO), the national trade association for the inland and coastal tug and barge industry.

AWSC members build and repair towboats and barges, offshore service vessels, fish and fish processing vessels, passenger vessels, oceanographic research vessels, as well as dredging vessels for the Army Corps of Engineers, U.S. Navy and Coast Guard vessels and vessels used by state and local governments for port management and safety.

Second-tier shipyards are a key component of the U.S. shipbuilding and ship repair capability. Second-tier yards are those shipyards that build and/or repair steel and aluminum vessels up to 600 feet in length. A second-tier shipyard employs anywhere from 15 to 3400 workers and operates on the inland river system, the Gulf Coast, the Pacific Northwest, the Great Lakes and East Coast. Historically, second-tier shipyards have been small, independent businesses, owned and operated by individuals or families and are managed by a relatively small staff. They are fiercely competitive and innovative. In fact, a few AWSC members have been successful in the international marketplace and build vessels for export. Despite unfair subsidy practices by foreign countries, the second-tier shipyards in operation today, while they still face many difficulties, have survived a severe industry downturn during the mid and late 1980's and have emerged leaner and better able to compete in today's tough market. Indeed, we see them rising to a new ascendancy by the end of the century because of their energy, productivity and competitiveness.

We believe that America must remain a maritime nation. There have been countless speeches and pronouncements to this effect over many years. This has been even more pronounced in the consideration of maritime reform legislation in the 102nd Congress, and, now again in this Congress. As we debate the steps necessary to maintain some semblance of a maritime nation, one that matches the nation's needs, let us remember that both the industrial strength and national security of the United States depend in significant measure on a strong and responsive shipbuilding industry. America must have the ability to design, build and repair all types and sizes of vessels, ranging from river tugs and barges to oceangoing cargo and military vessels. We have arrived at a time when decisive action by the Administration and Congress is needed to reach and

maintain this important goal. During our nation's history we have equipped ourselves to fight wars, cure diseases and fly to the moon. All of these challenges have been met for the purpose of protecting the common good and enhancing the quality of life. By revitalizing the U.S. maritime industry, and the shipyards that service it, we will again remain faithful to of our predecessors by doing the right thing for America.

At this point I would like to offer some general comments and observations about what should be done to address the problems we face.

In the long term the Congress must act on measures that will increase our competitive strength. I emphasize this element because the future of U.S. shipyards will be determined primarily on whether or not they are capable of building and repairing vessels in a cost efficient, high quality, on-time delivery fashion. The same holds true for all other industries. Therefore, the Congress and the Administration must put in place measures that will equip U.S. shipyards with the tools to design, build and successfully market vessels throughout the world. In support of this goal, I offer·the following suggestions:

1. Federal agencies such as the Department of Commerce, the Maritime Administration and the Export-Import Bank must be energized with the mission of actively promoting the U.S. shipyard industry. If reorganization is necessary to make agencies and Departments perform for the people, so be it. U.S. shipyards need a strong advocate to promote U.S.-built products. The three agencies I just mentioned have the basic structure to address this challenge but their performance has not matched the need. Many times, market opportunities are lost due to the unavailability of sufficient financing. We cannot allow this to continue. This is not a plea for some type of government subsidy. Instead it is a call to effective, realistic and sure action for the federal government to be a legitimate business partner with U.S. industry.

2. Realistic efforts to unify U.S. and international building standards must be brought to a successful conclusion. Progress has been glacial, however. Efforts by the Shipbuilders Council of America and the Coast Guard have been particularly beneficial. I hasten to point out that a similar effort must be undertaken for small and medium size vessels and equipment.

3. Continued action and funding of the Sealift modernization program is a must. Since over 90% of the personnel and equipment used to support the deployment of American troops is moved on cargo vessels, a dependable sealift capability is indispensable to our national security. While helping to fulfill the paramount goal of bolstering our national security, a vigorous sealift modernization program will also present opportunities for second-tier shipyards.

4. AWSC supports the shipbuilding technology program sponsored by the Advanced Research Projects Agency (ARPA). This effort is part of the overall Technology

Reinvestment Project aimed at helping defense related industries make a transition to civilian oriented products. This program shows signs of promise and it deserves the active support of the Administration, the Congress and industry. However, many other ambitious programs in the past have yielded disappointing results and we will have to wait and see what happens with this one.

AWSC believes that joint government/industry cost sharing programs can be of benefit, if they are well organized and focused. To this end, AWSC will submit a proposal to ARPA that includes joint industry/government funding of a market study to identify international commercial market opportunities. In addition, the AWSC project will generate up to five innovative vessel designs and manufacturing systems to produce these vessels in a faster and cost efficient way. Finally, our proposal would identify financial aids, such as loan guarantees tailored to the specific needs of second-tier shipyards as well as the establishment of an Export Trading Company to facilitate sales of U.S.-built products.

AWSC urges this committee to support the ARPA program and a sustained investment in technology development.

5. Some of our foreign competitors enjoy subsidies and other promotional advantages from their respective governments. This has distorted market conditions. The trade negotiations held under the auspices of the Organization for Economic Cooperation and Development (OECD) have failed to produce an agreement on a process to reduce and eliminate government subsidies. We are grateful to Rep. Gibbons for introducing H.R. 1402 and for forcing Congress and the Administration to focus on this problem.

The solutions to our problems are achievable. Are the problems serious? Yes, of course. Are foreign subsidies part of the problem? Yes, but let us not deceive ourselves that this is the sole problem. The answer lies in timely and sustained efforts in the public and private sectors, united in a new, dedicated, and vigorous partnership.

As Americans we are united in our desire to do the right thing for our country. Every measure we take as public officials and involved citizens is guided by this principle. In boosting the U.S. shipyard industry we are helping this nation prosper and grow stronger. This is a tall challenge, but we have met many fearsome challenges in the past. This challenge can and must be met.

Mr. Chairman, once again I want to thank you for the invitation to appear today as well as for the efforts by you and Chairman Studds on behalf of the U.S. maritime industry and the shipyards that support it.

AMERICAN WATERWAYS SHIPYARD CONFERENCE
1600 Wilson Boulevard, Suite 1000, Arlington, Virginia 22209 Phone: (703) 841-9300 Fax: (703) 841-0389

AWSC MEMBERS

ALABAMA	
Alabama Shipyard/Atlantic Marine, Inc.	Mobile, Alabama
Bender Ship Repair Company, Inc.	Mobile, Alabama
Harrison Brothers Dry Dock	Mobile, Alabama
Steiner Shipyard, Inc.	Bayou La Batre, Alabama
FLORIDA	
Gulf Marine Repair Corporation	Tampa, Florida
Trinity Marine - Panama City	Panama City, Florida
GEORGIA	
Savannah Marine Service	Savannah, Georgia
ILLINOIS	
National Maintenance and Repair, Inc.	Hartford, Illinois
INDIANA	
Corn Island Shipyard	Lamar, Indiana
Jeffboat	Jeffersonville, Indiana
KENTUCKY	
Walker Boat Yard	Paducah, Kentucky
LOUISIANA	
Acadian Shipyard, Inc.	Bourg, Louisiana
Algiers Iron Works, Inc.	Algiers, Louisiana
Aluminum Boats (Trinity Marine Group)	Crown Point, Louisiana
Bollinger Machine Shop and Shipyard, Inc.	Lockport, Louisiana
Bollinger Quick Repair	Harvey, Louisiana
Bourg Dry Dock and Service Company	Bourg, Louisiana
Contifleeting	New Orleans, Louisiana
Equitable Shipyards (Trinity Marine Group)	New Orleans, Louisiana
Equitable - Madisonville (Trinity Marine Group)	Madisonville, Louisiana
Gretna Machine and Iron Works (Trinity Marine Group)	Harvey, Louisiana
Halter Marine (Trinity Marine Group)	Lockport, Louisiana
HBM River Plant, Inc.	Baton Rouge, Louisiana
Lash Marine Services, Inc./Int'l Shipholding Corp.	New Orleans, Louisiana

Louisiana, continued

McDermott Shipyards	Amelia, Louisiana
Plaquemine Point Shipyard	Sunshine, Louisiana
Quality Shipyard, Inc.	Houma, Louisiana
Service Marine Industries	Amelia, Louisiana
T.T.Barge Cleaning, Inc./T.T.Coatings, Inc.	Harahan, Louisiana
Tiger Shipyard, Inc.	Port Allen, Louisiana

MISSISSIPPI

Halter - Moss Point (Trinity Marine Group)	Moss Point, Mississippi
Mississippi Marine Corporation	Greenville, Mississippi
Moss Point Marine (Trinity Marine Group)	Escatawpa, Mississippi
Superior Boat Works, Inc.	Greenville, Mississippi
Trinity Marine - Gulfport	Gulfport, Mississippi

MISSOURI

Missouri Dry Dock and Repair Company, Inc.	Cape Girardeau, Missouri

NEW JERSEY

Union Dry Dock and Repair Company	Hoboken, New Jersey

OHIO

McGinnis, Inc.	South Point, Ohio

OREGON

Gunderson, Inc.	Portland, Oregon
Sundial Marine Tug and Barge Works, Inc.	Troutdale, Oregon

PENNSYLVANIA

Hillman Barge Co. (Trinity Marine Group)	Brownsville, Pennsylvania

TEXAS

Bludworth Bond Shipyard, Inc.	Houston, Texas
Carotex Inc.	Port Arthur, Texas
Channel Shipyard Company, Inc.	Baytown, Texas
Galveston Shipbuilding Company	Galveston, Texas
Glendale Boat Works, Inc.	Channelview, Texas
Gulf Copper and Manufacturing, Inc.	Port Arthur, Texas

Texas, continued

John Bludworth Marine, Inc.	Pasadena, Texas
Newpark Shipbuilding and Repair, Inc.	Houston, Texas
Orange Shipbuilding Company, Inc.	Orange, Texas
Platzer Shipyard, Inc.	Houston, Texas
Southwestern Barge Fleet Service, Inc.	Channelview, Texas
Trinty Marine - Beaumont	Beaumont, Texas

VIRGINIA

Davis Boat Works, Inc.	Newport News, Virginia
Lyon Shipyard, Inc.	Norfolk, Virginia
Norfolk Shipbuilding and Dry Dock Corporation - Brambleton Plant	Norfolk, Virginia
Tidewater Equipment Corporation	Chesapeake, Virginia

WASHINGTON

Duwamish Shipyard, Inc.	Seattle, Washington
Fishing Vessel Owners Marine Ways, Inc.	Seattle, Washington
Foss Shipyard	Seattle, Washington
Marco Seattle, Inc.	Seattle, Washington
Marine Industries Northwest, Inc.	Tacoma, Washington
Nichols Bros. Boat Builders, Inc.	Freeland, Washington
Pacific Fisherman, Inc.	Seattle, Washington
Westport Shipyard, Inc.	Westport, Washington

WISCONSIN

Peterson Builders, Inc.	Sturgeon Bay, Wisconsin

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Statement By
John J. Stocker, President
Shipbuilders Council of America

Before

Subcommittee on Merchant Marine
Committee on Merchant Marine & Fisheries

Re: Maritime Revitalization &
Foreign Shipbuilding Subsidies

1334 Longworth House Office Building
Washington, DC 20515

June 30, 1993

Mr. Chairman, Members of the Subcommittee, my name is John J. Stocker. I am President of the Shipbuilders Council of America, the national trade association representing American shipyards, marine equipment suppliers, and naval architects. A membership list is attached to my written testimony.

I appreciate the opportunity to express our industry's views on H.R. 2151 (a bill to amend the Merchant Marine Act, 1936, to establish the Maritime Security Fleet program), H.R. 2152 (a bill to amend the Merchant Marine Act, 1936, to encourage merchant marine investment), the Shipbuilding Trade Reform Act of 1993 (H.R. 1402), the Shipbuilding and Ship Repair Free Trade Act of 1993 (S. 990), and legislation that is currently being discussed regarding shipbuilding market access measures.

First of all, let me thank the Chairman and the members of the subcommittee for their leadership in dealing with issues concerning maritime reform and assisting the U.S. shipbuilding and ship repair industries in attaining a competitive position in the world marketplace.

It has now been four years since the Shipbuilders Council of America filed a Section 301 petition with the United States Trade Representative, and over a year

since the international trade negotiations responding to that petition collapsed. During this period, the situation for American yards has gotten steadily worse. With the significant downsizing of the naval fleet during the remainder of the 1990s, the U.S. shipbuilding industry is facing massive layoffs and yard closures. By 1998 there will be only one or two American yards left that can build big ships, unless the industry gains access to commercial ship construction contracts in the next couple of years. But this can only happen in a market that is undistorted by subsidies.

American shipyards are an integral part of our country's critical manufacturing industrial base. Ship construction represents one of the must difficult and complex manufacturing processes in the world, surpassing aircraft and missiles. Because it requires many kinds and levels of expertise, it provides work for every socio-economic segment in our society, including entry-level jobs for relatively unskilled urban workers, jobs for skilled industrial workers, and high-technology jobs for degreed engineers.

Furthermore, shipbuilding provides a market stimulus for more basic industries than aircraft or any other product. This is because a ship is a small floating city, requiring both large and small sizes of engines, generators, motors, pumps, valves, winches, and electrical control equipment, in addition to electrical cable, electronic navigation equipment, radios, and, of course, very large

quantities of steel plate. This is why, for every job in an American shipyard, another three jobs are created. A modest shipbuilding program of 50 ships a year would produce approximately 100,000 American jobs in shipyards and shipyard supplier industries.

In other words, America's shipyards are good for the long-term economic well-being of the country, as well as essential for ensuring that the United States has the necessary domestic shipbuilding skills and facilities available to meet our country's defense requirements as they arise.

The U.S. shipbuilding industry has gone without subsidies since 1981, when the U.S. government unilaterally ended the Construction Differential Subsidy (CDS) program for U.S.-flag ships built in U.S. yards. Unfortunately, the timing could not have been worse. International commercial shipbuilding was in the blackest market depression in history, and the governments in all shipbuilding countries except the United States were escalating aid programs for their yards.

By propping up their shipbuilding industries in the 1980s through subsidies and other means, foreign governments not only drove unsubsidized U.S. yards out of the commercial shipbuilding, they encouraged the dumping of ships on an unprecedented scale. At the lowest point, Asian and European shipyards were barely covering half their production costs.

The working group on shipbuilding in the Organization for Economic

Cooperation and Development, known as the OECD, recognized the anti-competitive, market-distorting effects of shipbuilding subsidies over ten years ago. In early 1983, 14 OECD nations signed a document in which they agreed not to introduce any new shipbuilding subsidies and to gradually eliminate the ones they already had. However, because the agreement did not include an enforcement mechanism, it was largely ignored.

A new draft agreement resulting from the subsequent OECD negotiations begun in 1989 contained a stringent enforcement mechanism. It also contained an antidumping provision. This agreement was never signed. In April 1992, the European Community, Japan, and South Korea scuttled the talks. The United States Government had underestimated the resistance of the European Community to giving up their shipbuilding subsidies and the insistence of the Japanese and South Koreans to retain ship dumping rights. Moreover, the U.S. Government had underestimated its own lack of muscle in the negotiations, because it had given away its bargaining chit through the unilateral termination of its commercial shipbuilding subsidy program in 1981.

There is another factor which is reinforcing the determination of the European Community, Japan, and South Korea to hold on to their subsidies: the current sluggish market. When the OECD talks began in 1989, the international shipbuilding market had emerged from the decade-long depression. New ship

orders were increasing significantly and prices were rising sharply. Most market analysts were forecasting a shipbuilding boom from that point on until the early 2000s.

As it has turned out, those market predictions were overly optimistic. Instead of continuing to move rapidly upward, the market has remained relatively sluggish, due to the prolonged economic recession, continuing low freight rates, and other problems. Nevertheless, the need to replace the aging and deteriorating ships of the world's merchant fleet remains. There will be an upswing in replacement ship orders, but not until the second half of the 1990s. It is critical to the future of the American shipbuilding industrial base that our yards be able to compete for contracts in this market without the intervention of foreign governments and their market-distorting subsidies.

The seriousness of these subsidy practices is best illustrated by a current case involving an American shipping company, American President Lines, and shipyards located in Germany and Korea. This transaction involving the construction of 12 container ships is typical of the kinds of distortions that are undertaken in the marketplace that affects, not only the domestic market, but the export market, as well.

Our information is that a contract was signed between APL and HDW in Germany and Daewoo in Korea for the ship construction. The initial contract is

for four vessels; two to be built at HDW and two to be built at Daewoo. Reportedly, the contract price for these ships is DM153.3 million per ship. In dollars terms, this equates to about $100 million per ship. However, recent studies by the European Economic Community indicate that the German shipyard costs, without subsidy, would equal approximately $140 million. Thus, the subsidy support being provided by the German Government and the guarantees of financial solvency being underwritten by the state of Schleswig-Holstein equals 40%.

This subsidy case is particularly important in that APL has been vigorously lobbying the U.S. Government for the right to buy ships built with foreign subsidies from overseas yards and to obtain funding from the U.S. Government for another 15 years to operate the ships under the U.S. flag. U.S.-flag ships must be owned and operated by U.S. citizens. To receive operating differential subsidies (ODS) from the government, they must also be U.S. built. Since the start of the ODS program, APL has received $1.5 billion from U.S. taxpayers, in addition to $77.6 million scheduled for fiscal year 1993 payouts.

Last fall [1992], APL solicited bids from U.S. yards for the new containerships, but gave them only 17 days to respond, an unrealistic timeframe that indicated the solicitation was only perfunctory and not serious. It is now clear that APL planned to get a subsidized contract from HDW all along, and has been maneuvering to obtain eligibility for operating subsidies from the U.S. Government

for these ships, just like it was able to do in the late 1980s for five ships of the same design.

At that time, APL ordered five containerships from German yards, with the German Government paying half the ships' contract price out of a combination of German defense funds, money funneled through a state-owned steel mill, and direct cash. In addition to the German subsidy, millions of dollars have been paid in subsidies by the U.S. Government in the operation of these ships, which were given a special exemption from the U.S.-build requirement.

Shipbuilding interests represent powerful political entities in the top shipbuilding subsidizing nations. Currently, foreign shipbuilders are intensifying political pressure on their governments to continue to receive subsidies. The Shipbuilders Council of America has just released a report which states that the top six subsidizing nations in the OECD are budgeting over **$9 billion** on average each year to help out their shipyards. Of the total amount, South Korea accounts for $2.4 billion, Germany for $2.3 billion, Japan for $1.9 billion, Italy for $940 million, Spain for $897 million, and France for $643 million.

These shipbuilding aid budget figures include, where known, loans and subsidized interest for ships built in the yards of the subsidizing countries; cash grants to shipyards paid as a percentage of the ship construction contract price; cash for shipyard operations, modernization, and rationalization; and ship and

shipbuilding-related research and development. What the figures do <u>not</u> include are the subsidy values of government guarantees and tax benefits, or the full amounts of ship construction and shipyard loans and research and development aid. In other words, the true value of shipbuilding aid in the six OECD countries is significantly higher than $9 billion.

What we must conclude is that our trading partners will hold on tightly to their shipbuilding and repair subsidies unless they have a strong enough incentive to discontinue them.

Before I begin my comments on the legislation that has recently been introduced by the Merchant Marine Committee leadership, let me comment on the legislative efforts being undertaken to solve this problem of foreign subsidy practices. I should emphasize that getting control of the foreign subsidy issue is critical to creating a future for the U.S. industry. Getting control of the foreign government distortions of the marketplace must be achieved because the industry clearly understands the limitations on the Treasury and the inability to construct the federal funding programs of the past.

The goal of H.R. 1402 (the Shipbuilding Trade Reform Act of 1993) is to provide an incentive to foreign countries that ties the discontinuation of shipbuilding subsidies and ship dumping practices to U.S. market access.

The Shipbuilders Council of America strongly supports H.R. 1402 and urges

71-836 O - 93 - 2

the members of this subcommittee to do likewise. I have attached to my written testimony a list of over 200 companies across the country who have joined 21 labor unions in endorsing this bill. Furthermore, we are confident that the current Administration is much more amenable to the legislation than the last Administration was.

Currently, shipbuilding manufacturers represent the only American industry which cannot seek redress for unfair trade practices under U.S. anti-dumping and countervailing duty (CVD) laws. Every other American industry--from automobiles to airplanes, from electronics to steel--are covered under these laws. Title 1 of H.R. 1402 amends U.S. anti-dumping and countervailing duty laws to make them applicable to ships.

I cannot emphasize enough the harm that has come to the U.S. shipbuilding base because of the fundamentally discriminatory and unfair exclusion of our industry from U.S. anti-dumping and CVD laws. International ship dumping practices, which were encouraged and supported by the massive shipbuilding subsidy programs of foreign governments throughout the 1980s, helped to destroy commercial ship construction in the United States. South Korea was the primary instigator of ship dumping practices. That government used its state bank to allow Korean yards to incur billions of dollars of debt while lowballing ship prices in order to capture market share. Japan followed South Korea's lead, then the

European shipbuilding countries.

Unfortunately, even our own government tacitly approved the practice of ship dumping and foreign shipbuilding subsidies, rationalizing that cheap prices, no matter how they were achieved, were in the consumer's best interest. Our country's legacy today from that short-sighted vision--which was applied to other American manufacturing sectors as well--includes a huge trade imbalance, the destruction of many American businesses, and the export of American jobs.

International ship dumping practices ameliorated in the early 1990s, but they continue as a threat whenever a foreign producer wants to undercut its competitors. That is why the aborted draft OECD agreement included an antidumping mechanism. U.S. shipowners are adamantly opposed to anti-dumping and CVD mechanisms--whether part of an international agreement or included in U.S. legislation--for the simple reason that they want cheap ships. We understand that some ship owners have gone so far as to hire lawyers to make a case for barring airplanes from current U.S. antidumping and CVD laws, thereby putting shipowners at odds with the American aerospace industry, which has always interpreted the law to cover airplanes.

It is interesting to noted that while some American shipowners oppose anti-dumping and countervailing duty applications for American shipbuilders, the services they provide are protected under unfair foreign competition industry-

specific laws under the Foreign Shipping Practices Act of 1988. This act, which is based on the Merchant Marine Act of 1920 and is administered by the Federal Maritime Commission, permits the imposition of fines and closure of U.S. ports to vessels of carriers benefiting from practices that adversely affect the operations of domestic carriers in U.S. oceanborne trade.

Title 2 of H.R. 1402 gets at the specific shipbuilding and repair subsidy practices of foreign governments. Here, too, the bill parallels the draft OECD agreement by generally adopting the OECD's subsidy definitions and by including an enforcement mechanism. The enforcement mechanism in H.R. 1402 is tailored along the lines of the U.S. Foreign Shipping Practices Act.

It is in the enforcement mechanism wherein the major differences between last year's bill and this year's bill lie. H.R. 2056--last year's bill--would have penalized all ships built in subsidized foreign yards after the date of the bill's enactment by denying entry of an affected ship to U.S. ports until the subsidized portion of the ship's price was paid back to the government that provided the subsidy, or paid to the U.S. Government in the form of a duty. This approach was consistent with current U.S. trade laws which allow for a duty to be placed on goods exported from countries that commit unfair trading practices, but the duty would have been levied only on the subsidized product itself, the ship. Payment of the duty would have been limited to the consumer who would most

directly benefit from the subsidy, the ship purchaser.

However, because of the strenuous objections from American shipowners, a different approach was taken in this year's bill. In H.R. 1402, penalties would be applied against ships domiciled or registered in, or owned by citizens of, countries that refuse to terminate their shipbuilding and repair subsidies. The penalty options are those which are contained in the U.S. Foreign Shipping Practices Act, such as placing a financial penalty of not more than $1 million per vessel per voyage, limiting the number of U.S. port calls for affected vessels, or closing off U.S. ports to such vessels.

As I stated before, these provisions have been part of U.S. law to combat unfair foreign shipping practices for years. They have been extremely effective, and they have not cost U.S. ports any business. Foreign shippers targeted by the FMC for unfair trading practices have stopped the practices rather than divert cargo from U.S. ports to Canadian or Mexican ports.

There is no reason to believe that applying these same provisions to stop shipbuilding subsidies will result in port diversion, simply because it would not make economic sense to switch to Canadian or Mexican ports merely to avoid the U.S. anti-subsidy legislation. If it is more cost-effective to use U.S. ports now, enactment of The Shipbuilding Trade Reform Act will not change that.

Determining the most cost-effective port involves not only the type and

capacity of port facilities to handle the cargo--all ports are not alike--but the land transportation links from the port to the customer. Remember, only 20 percent of a carrier's cost are involved in seaborne transportation; 80 percent of the cost comes from what happens to the goods on land.

Nevertheless, to prevent any possibility of cargo diversion from U.S. ports, and to specifically address the stated concerns of some ports last year, H.R. 1402 provides that the Department of Commerce direct the U.S. Customs Service to deny U.S. entry of cargo that has been transported from Canadian or Mexican ports on ships affected by the legislation. Some concerns have been raised as to whether such a provision would be in violation of Article V of the GATT (General Agreement on Tariffs and Trade), which requires goods in transit to move freely through the territory of a party. However, Article V makes an exception in "cases of failure to comply with applicable customs laws and regulations." The authority of the Customs Service to deny entry of cargo into the United States was established under the Foreign Shipping Practices Act, and no complaint has ever been filed, or even raised, with the GATT.

In the Senate, the Shipbuilding and Ship Repair Free Trade Act of 1993 (S. 990) has been introduced. It differs from the House bill by not including Title I of H.R. 1402 regarding the CVD and anti-dumping provisions in its bill. While we support the legislation, we believe that government supported dumping

practices are so pervasive that there must be a method to prevent such practices from harming U.S. shipbuilders and, as a result, the anti-dumping provision must be included in any final version of anti-subsidy legislation.

In regard to the maritime reform legislation, we congratulate the Committee in moving aggressively to address the issues that have, to this point, not received extensive Administration support. In H.R. 2151, we understand that the Committee is attempting to modernize the government support programs for U.S.-flag operators. We believe that we are not in a position to comment on issues of ship operations. However, we are concerned about efforts to open U.S. market access to subsidized foreign-built ships and we, therefore, support the language in Section 403 (b) (2) that prohibits a U.S.-flag carrier from building in a foreign subsidized shipyard. It should be noted, however, that the cut-off date of May 19, 1993, will not prevent APL from bringing into the U.S. market 12 ships to be built in Germany and Korea, two countries that have been most responsible for the chaos that currently operates in the international market.

Secondly, the Committee needs to be aware that we are concerned that the language in Sec. 403 (b) (4) (B) that permits the introduction of second-hand ships into the U.S.-flag inventory would allow operators to purchase ships that were built in subsidized foreign shipyards as long as they are no older than 10 years of age. This would seem to circumvent the intent of Sec. 403 (b) (2) and reward the

foreign subsidizers for their behavior.

In regard, to H.R. 2152, we support the intent of the efforts being made in that legislation that intends to modernize the Capital Construction Fund program and pledge our efforts to work with the Committee on obtaining passage of the bill.

Finally, there has been considerable discussion of late of more directed and specific programs to assist U.S. shipyards in gaining market access to the future global market. We want to thank the committee members and staff for the work that has gone into the legislation that was introduced yesterday. We believe that the legislation will address many of the concerns we have about improving our competitiveness and can be made to fit within an overall U.S. trade policy that searches for an international solution to the problems of foreign government distortions of the marketplace. While it is difficult to know if the combination of research and development, Title XI re-structuring, series production support, and chartering of double-hull tankers by the Defense Department is the right mix, it is our view that all options must be explored.

Our unsubsidized industry is on the brink of destruction. Our yards cannot fight foreign governments. Furthermore, unless our government acts quickly, it will not only be American shipyards and American shipyard workers who will be

affected, but also the country's steel mills, marine equipment manufacturing plants, and the more than 1,000 other U.S. shipyard supplier industries. By 1998 we will have another 180,000 Americans in the unemployment lines unless something is done now to enable American shipyards to re-enter the commercial market--a market undistorted by subsidies.

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Industrial Union Dept., AFL/CIO
International Association of Plumbers and Pipefitters
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Shipbuilders Council of America

INTERNATIONAL SHIPBUILDING AID

June 1993

INTERNATIONAL SHIPBUILDING AID

Shipbuilding Aid Practices of the Top OECD Subsidizing Nations and Their Impact on U.S. Shipyards

June 1993

EXECUTIVE SUMMARY

THIS UPDATED REPORT ON FOREIGN SHIPBUILDING SUBSIDY PRACTICES:

- IDENTIFIES the current top shipbuilding subsidizers in the Organization for Economic Cooperation and Development (OECD) and describes how much and what kind of government aid these nations are budgeting for their domestic commercial ship construction yards.

AVERAGE ANNUAL SHIPBUILDING AID BUDGETS OF TOP SUBSIDIZING OECD NATIONS SINCE 1988

Country	Ship Financing		Direct Yard Aid			R&D	Annual Average*
	Loans, Subsidized Interest	Guarantees	Contract Grants	Shipyard Capital*	Yard Loans, Interest Sub.		
S. KOREA	YES $1.8b	YES	Unknown	YES	YES $595m	YES	$2.4B
GERMANY	YES $1.5b	YES	YES $353m	YES $463m	YES Amt. unkwn	YES	$2.3B
JAPAN	YES $818m	YES	SOME	YES $85m	YES	YES $1b	$1.9B
ITALY	YES $557m	Unknown	YES $175m	YES $184m	Unknown	YES $24m	$940M
SPAIN	YES $306m	YES	YES $153.5m	YES $438.2m	YES	YES	$897M
FRANCE	YES $399m	YES	YES $149m	YES $83m	Unknown	YES $3m	$634M

**Excludes sums and subsidy values of government guarantees.*

- DELINEATES the specific shipbuilding aid practices of the six top subsidizing nations in the OECD in two to four-page summaries for each country.

- PROVIDES examples of shipbuilding aid actions in the six countries, such as:

  South Korea: A $750 million-plus government rescue package began in 1990 for the Daewoo shipyard, a $492 million ship design automation program was set up by the government in 1990, and a government-subsidized industrial park for ship machinery production to help Korean shipyards was announced in early 1993.

  Germany: A $4 billion subsidy package to modernize, restructure, and cover the losses of the shipyards in former East Germany was approved by the European Community in 1992. Most of the money goes to the western shipbuilding conglomerates of Bremer Vulkan and Kvaerner, who have taken over the largest yards in eastern Germany.

Japan: Government support of ship design and shipbuilding-related research and development has been escalating since 1989, currently amounting to over $1 billion annually. Major current programs: R&D for 21st century vessels, established in 1989; development of an environmentally-sensitive double hull tanker, announced in December 1990.

Italy: In January 1992, the Commission of The European Community approved $224 million in loss compensation granted by the Italian government to the state-owned shipbuilding conglomerate Fincantieri for 1990, plus an additional $27 million in restructuring aid.

Spain: The government routinely covers losses of the state-owned AESA shipbuilding conglomerate. In 1992, these losses amounted to $95 million.

France: The French government is subsidizing the entire 1993 orderbook of oceangoing ships (5 LNG tankers, 3 cruiseships) at the country's main yard, Chantiers de L'Atlantique. Total subsidy amounts are in dispute since the government refuses to confirm them. The estimated range is from a low of $303 million to a high of $438 million.

- CITES recent (1992/1993) specific subsidized contracts, such as:

  The three-containership contract between the Japanese shipyard Hitachi and China Ocean Shipping Co. (COSCO) subsidized by the Japanese government at 25.17%, with a 14-year soft loan (8-year grace period). . . . The five-containership contract between Spanish state-owned AESA shipbuilders and TMM of Mexico subsidized by the Spanish government at 27.5%, with a 30-year soft loan (14-year grace period) at 3.4% interest. . . . The cruise ship contract between state-owned Fincantieri shipbuilders and P&O Princess Cruises eligible for Italian government subsidies equivalent to 39%. . . . The two-containership contract between Bremer Vulkan's MTW yard and an Indonesian-flag company which will receive a 12-year loan from the German government at 4.25% interest, and is eligible for a subsidy up to 36% of the contract price.

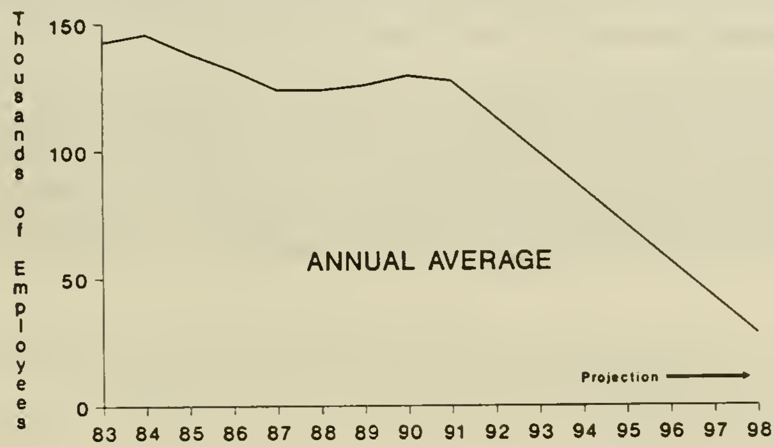
THIS REPORT DESCRIBES THE DEVASTATING IMPACT OF FOREIGN SHIPBUILDING SUBSIDIES ON U.S. INDUSTRY

- Before 1981, U.S. shipbuilders had a balanced and profitable workload of commercial and military ships. After 1981, however, the combined impact of escalated foreign shipbuilding subsidies, international ship dumping practices, the unilateral termination of the U.S. Construction Differential Subsidy program and the granting of "Section 615" waivers to U.S. shipowners devastated commercial shipbuilding in the United States and forced surviving U.S. yards to depend on the U.S. government as their sole source of business.

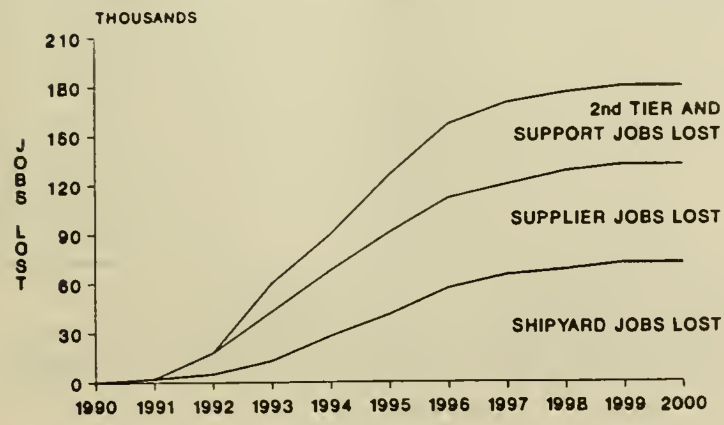
- Because of cuts in the U.S. defense budget and the severely reduced requirements for new Navy ships for the remainder of the 1990s, most of the country's private shipyards will have to close by 1998, unless there is a resurgence of commercial shipbuilding. But the transition to building commercial ships cannot be successful unless foreign shipbuilding subsidy practices are terminated.

- Unless the U.S. government is successful in convincing foreign governments to end their ship dumping and shipbuilding and repair subsidy practices, there will be only one or two major yards left in the country by 1998, and 180,000 Americans will lose their jobs in the U.S. shipyard and shipyard supplier industries.

DECLINE IN TOTAL EMPLOYMENT AT U.S. PRIVATE SHIPYARDS



TOTAL JOBS LOST FROM U.S. SHIPYARD/SHIPYARD SUPPLIER BASE, 1990-2000



<u>180,000 Jobs Lost by Fiscal Year 1999</u>:
72,000 Shipyard Jobs
60,000 Supplier Jobs
48,000 2nd Tier and Support Jobs

THIS REPORT CONCLUDES THAT ONLY U.S. LEGISLATION CAN PROVIDE A STRONG ENOUGH INCENTIVE FOR OECD NATIONS TO AGREE TO END THEIR SHIPBUILDING AND REPAIR SUBSIDY PRACTICES

- The governments of 14 OECD countries ignored the document they signed in early 1983 in which they agreed not to introduce any new shipbuilding subsidies and to gradually eliminate their current ones. In April 1992, they walked away from nearly three years of international negotiations by refusing to sign a draft agreement to end their shipbuilding and ship repair subsidy practices.

- Shipbuilding interests represent powerful political entities in the top shipbuilding subsidizing nations in the OECD, and their desire to continue to receive government subsidies is having a dominant influence on the political will of their governments to end the subsidies. Because the U.S. government discontinued its one direct commercial shipbuilding subsidy program in 1981, it lost its bargaining chit in international negotiations. Only by tying the discontinuation of shipbuilding subsidies to entry to U.S. markets can the U.S. government apply sufficient pressure on its trading partners to stop their shipbuilding and ship repair subsidy practices. This is the goal of the current anti-subsidy legislation in the U.S. Congress, The Shipbuilding Trade Reform Act of 1993; H.R. 1402 in the House and S. 990 in the Senate.

BACKGROUND ON FOREIGN SHIPBUILDING SUBSIDIES

Massive Subsidization During the 1980s - During the 1980s, foreign subsidies increased to massive levels, in response to the worldwide shipbuilding depression that followed the oil crisis of the mid 1970s. Foreign governments competed against each other for the biggest shipyard subsidy budgets. The Japanese government created a cartel for its largest shipbuilders, bought up and closed unproductive facilities, funded shipbuilding production and technology improvements, provided soft loans for purchases of Japanese-built ships, and paid Japanese shipowners to scrap their old ships and build new ones in Japanese yards. The South Korean government used its bank to finance the buildup of Korean shipyards and keep them afloat while they lowballed prices, incurred losses, and accumulated billions of dollars worth of debt. European governments pumped money into their shipyard facilities and enticed customers to their yards with cash grants and soft financing.

Ship Dumping - In conjunction with massive subsidies, the governments of South Korea, Japan, and Europe propped up their shipyards by supporting below-cost ship production practices. The following table illustrates Japanese shipbuilding cost/price relationships from 1982 through 1989. It is important to note that the table does not reflect that portion of production costs borne by the Japanese government in underwriting modernization of shipyard facilities and improvements in shipbuilding production processes, as well as other subsidy practices.

JAPANESE SHIPBUILDING COST/PRICE RELATIONSHIPS

Year	% of Total Cost Covered by Price	% of Total Cost Not Covered by Price
1982	88.75%	11.25%
1983	77.50%	22.50%
1984	66.25%	33.75%
1985	55.00%	45.00%
1986	62.50%	37.50%
1987	70.00%	30.00%
1988	77.25%	22.75%
1989	84.50%	15.50%

From analysis of Joseph W. Cummiskey, submitted in a Masters Thesis submitted to the Naval Postgraduate School, Monterey, Calif., December 1990, and based on data from four studies: Jenks & Larner, 1981; Jenks & Landsburg, 1985; Porter & Cho, 1985; Carson & Lamb, 1989 (with revised overhead estimates).

Japan's ship dumping practices followed the lead set by South Korea. In turn, European shipyards adopted dumping practices as part of their efforts to be competitive with South Korea and Japan. As stated by Drewry Shipping Consultants, European governments "allowed yards to run up substantial losses on newbuildings operations and have underwritten such losses." [World Shipbuilding Market: Prospects to 2000, November 1988] In 1990, for example, an audit of shipyards during 1989 in what was then West Germany showed that the largest yards produced merchant ships at prices averaging 26 percent below costs, before subsidies.

IMPACT OF FOREIGN SUBSIDIES ON U.S. YARDS

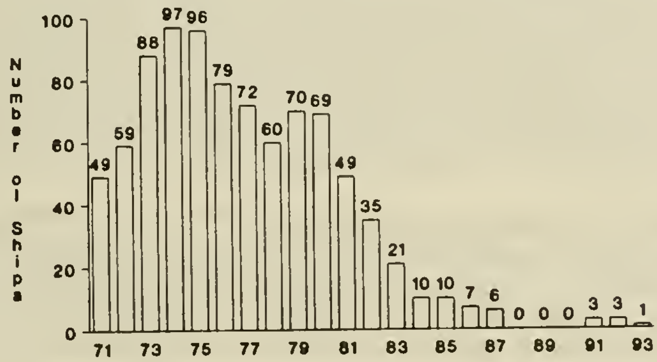
Overview - Before 1981, U.S. shipbuilders had a balanced and profitable workload of commercial and military ships. After 1981, however, the combined impact of escalated foreign shipbuilding subsidies, international ship dumping practices, the unilateral termination of the U.S. Construction-Differential Subsidy program and the granting of "Section 615" waivers to U.S. shipowners devastated commercial shipbuilding in the United States and forced surviving U.S. yards to depend on the U.S. government as their sole source of business.

Unilateral Termination of CDS - In 1981, as foreign shipbuilding subsidies were escalating, the U.S. government unilaterally terminated the commercial ship Construction-Differential Subsidy (CDS) in the United States. This program paid subsidies to U.S.-flag shipowners for having their ships built in the United States. Unlike the expansive shipyard subsidy programs of other shipbuilding nations, the U.S. program was tied to a relatively small domestic market and excluded the export market.

Section 615 Exemptions - Concurrent with the termination of CDS, the U.S. government implemented special legislation to encourage U.S. shipowners to bypass American shipyards and take advantage of foreign shipbuilding subsidies. This measure was embodied in an amendment to Section 615 of the Merchant Marine Act. It allowed U.S.-flag operators receiving operating-differential subsidy (ODS) payments from the U.S. government to buy from subsidized foreign yards during a temporary one-year "window" that subsequently was stretched to five years through the buying and selling of Section 615 rights approved by the Department of Transportation. Thus, the U.S. government succeeded in removing U.S. yards from the domestic commercial ship construction market. The Maritime Administration granted 50 Section 615 waivers. Of the 44 waivers which resulted in orders actually placed, 33 were for new construction and 9 were for conversions or retrofits. All but 3 of the 33 new ships ordered from foreign yards were built in the three countries that most heavily distorted the shipbuilding marketplace with subsidies during the 1980s: South Korea, Japan, and Germany. **The following table gives the details for 21 of the 33 Section 615 new construction ships built with subsidies overseas.**

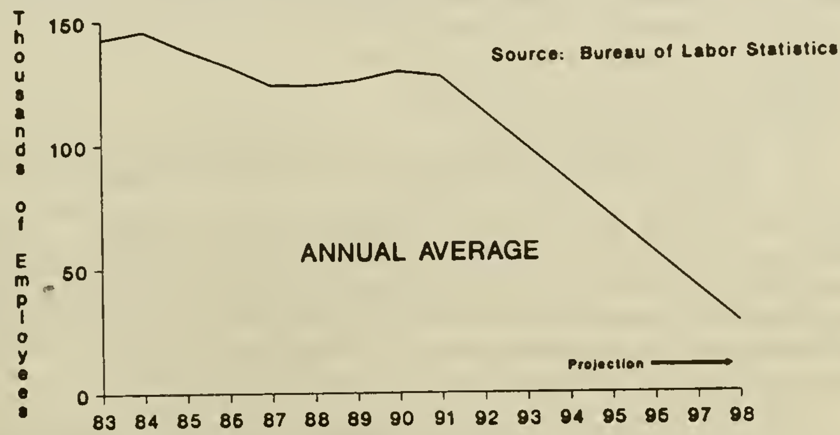
Owner/Ships	Country Yard	Dates	Price/ % Below Cost/ Subsidy	Real Cost
American Pres. Lines 3 C-10s; 4,340 teu *52,700, 54,600, 54,700 dwt*	Germany HDW	Contract: 10/86 Delivered: 4/88, 7/88, 9/88	*Price:* $61m (dm108.6m) ea *Below Cost:* At least 27%; 50% with 23% ($14m) subsidy	$ 83.6m +$14m sub. = $97.6m
American Pres. Lines 2 C-10s; 4,340 teu *54,600, 54,700 dwt*	Germany Bremer Vulkan	Contract: 11/86 Delivered: 7/88, 9/88	Price: $61m (dm108.6m) ea Below Cost: At least 22%; 45% with 23% ($14m) subsidy	$ 78m + $14m sub = $92m
U.S. Lines 12 containerships *4) 58,500 dwt* *7) 58,600 dwt* *1) 58,900 dwt*	S. Korea Daewoo	Contract: 4/21/83 Delivered: 6/84 -9/85	$55.75m ea At least 22.5% below cost.	$71.94m

NEW MERCHANT VESSELS UNDER CONSTRUCTION OR ON ORDER AT U.S. PRIVATE SHIPYARDS (JAN. 1, EACH YEAR)

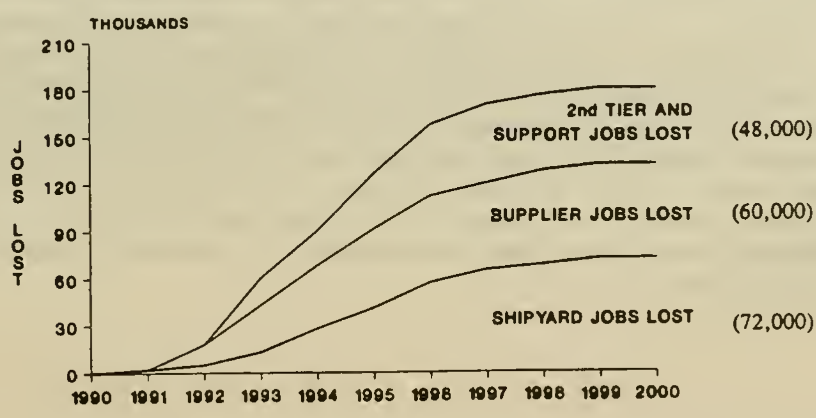


Future of U.S. yards - Unless foreign shipbuilding and ship repair subsidies are ended, the future of the U.S. shipbuilding industrial base is bleak. The significant downsizing of the naval fleet during the remainder of the 1990s means that the U.S. shipbuilding industry is facing massive layoffs and yard closures unless it can compete for commercial ship construction contracts in an unsubsidized market. At stake are 180,000 jobs, not only from U.S. yards but also from U.S. industries that supply the shipyards.

DECLINE IN TOTAL EMPLOYMENT AT U.S. PRIVATE SHIPYARDS



TOTAL JOBS LOST FROM U.S. SHIPYARD/SHIPYARD SUPPLIER BASE, 1990-2000



TRADE NEGOTIATIONS TO END FOREIGN SHIPBUILDING SUBSIDIES

The 1983 OECD RGA - In the early 1980s, the international community was already recognizing the destabilizing effect shipbuilding subsidies were having on the marketplace. Consequently, the governments of 14 countries within the Organization for Economic Cooperation and Development (OECD) signed a document in which they agreed not to introduce any new shipbuilding subsidies and to gradually eliminate their current ones. Called the Revised General Arrangement (RGA), the agreement went into effect in early 1983. However, the agreement was generally ignored, largely because of the absence of an enforcement mechanism.

Instigation of New Subsidy Negotiations in 1989 - In June 1989, on behalf of the U.S. shipbuilding and repair industry, the Shipbuilders Council of America filed a petition under Section 301 of the U.S. Trade Act. In response, the U.S. Trade Representative agreed to initiate negotiations within the OECD, assuring U.S. shipbuilders that agreement could be reached among our trading partners within nine months. However, after three years of negotiations and several missed deadlines, there was still no agreement, and in April 1992, the negotiations collapsed.

The OECD Draft Agreement - The various drafts of the anti-subsidy agreement drawn up by the OECD's Working Party Six expanded upon the 1983 RGA. The last working draft was divided into four major sections: <u>The Preamble and the Articles</u> comprising the body of the text which outlined the agreement's thrust, scope, and procedures, including the dispute mechanism and enforcement provisions; <u>Annex I</u>, which described the types of direct and indirect subsidies to be phased out; <u>Annex II</u>, which provides the subsidy phase-out schedule; <u>Annex III</u>, which amended the antidumping code of the GATT to make it applicable to ships; and <u>Annex IV</u>, the detailed procedures for establishing the Dispute Panel to hear a complaint brought against a signatory of the document.

U.S. Trade Legislation - Subsequent to the collapse of the OECD negotiations, the House of Representatives in May 1992 passed, on a 339 to 78 vote, a bill to send a strong message to our trading partners that the foreign subsidies which are destroying the American shipbuilding and repair industry would no longer be tolerated. The bill was introduced by Sam Gibbons (D-Fla.), Chairman of the House Ways and Means Subcommittee on Trade. A well-known advocate of free-trade, Congressman Gibbons insisted that "subsidized trade is not free trade." Over 200 U.S. companies joined 21 labor unions in formally requesting Congress to approve the legislation. However, the bill was stalled in the Senate.

On March 18, 1993, Representative Gibbons and 22 co-sponsors introduced a new anti-shipbuilding subsidy bill in the House, H.R. 1402, The Shipbuilding Trade Reform Act of 1993. A similar bill, S. 990, was introduced in the Senate on May 19, 1993, by Senators John Breaux, Barbara Mikulski, Trent Lott, Majority Leader George Mitchell, and 17 other co-sponsors. The purpose of the bi-partisan bills in the House and the Senate are designed to discourage foreign shipbuilding and repair subsidies, and to provide remedies against foreign governments which refuse to terminate these unfair trade practices. Both bills provide for sanctions to be placed against ships owned or controlled by citizens of the subsidizing country or registered in the subsidizing country. The House bill has a provision to amend U.S. countervailing and antidumping duty laws to make them applicable to subsidized or dumped ships; the Senate version does not.

CONTINUING SHIPBUILDING SUBSIDY PRACTICES IN OECD NATIONS

Situation in 1989 - When the U.S. Trade Representative instigated the shipbuilding and repair subsidy negotiations in the summer of 1989, it appeared that the OECD nations might be amenable to signing an agreement to end their subsidy practices. After all, the decade-long market depression had ended. New ship orders during the spring quarter had increased by 67 percent over the same quarter in 1988. Significant reductions had been made in shipbuilding capacity so that the supply/demand ratio was in better balance, and the dramatic increase in ship prices reflected this. For example, the 1989 price of oil tankers 80,000 deadweight tons (dwt) and above averaged 127 percent more than their prices in 1985.

Most market analysts predicted a shipbuilding boom, lasting into the 2000s. Government attempts to secure market niches for their domestic yards began shifting away from cash grants and shipyard operating aid to government financing programs. However, after the negotiations had gone on for several months, the reluctance of the European Community (EC) to give up their subsidy practices and the Japanese and South Koreans to give up their right to dump ships became increasingly clear.

Situation When the OECD Talks Collapsed - By the time the Europeans and Asians walked away from the OECD talks in April 1992, another shift had taken place in market conditions. The 1988 and 1989 forecasters had been too optimistic. Although the need for replacement of the aging and deteriorating ships in the world fleet was clear, a prolonged economic recession, continuing low freight rates, and various market uncertainties combined to slow down the rate of new ship ordering. Forecasters put off the anticipated shipbuilding boom until the second half of the 1990s. Intense political pressure was--and continues to be--applied by foreign shipbuilders to keep their subsidies, particularly in France, Germany, Italy, and Spain.

As a result, governments in the EC, Japan, and South Korea have tried to divert attention away from the <u>hundreds</u> of commercial ship orders they have subsidized and are continuing to subsidize, and focus culpability on the U.S. Jones Act, the cabotage law under which <u>four</u> ships (a containership and three sulfur carriers) ordered for the domestic trades since 1988.

Conclusion - Shipbuilding interests represent powerful political entities in the top shipbuilding subsidizing nations in the OECD, and their desire to continue to receive government subsidies is having a dominant influence on the political will of their governments to end the subsidies. Because the U.S. government discontinued its one direct commercial shipbuilding subsidy program in 1981, it lost its bargaining chit in international negotiations. Only by tying the discontinuation of shipbuilding subsidies to entry to U.S. markets can the U.S. government apply sufficient pressure on its trading partners to stop their shipbuilding and ship repair subsidy practices. This is the goal of the anti-subsidy legislation in the U.S. Congress.

The Top OECD Subsidizers - The remainder of this report summarizes the current shipbuilding aid practices of the six top shipbuilding subsidizers in the OECD: South Korea, Germany, Japan, Spain, Italy, and France. The concentration on these countries in no way implies that the remaining European countries within the OECD do not subsidize their commercial shipyards. On the contrary, all of them provide shipbuilding-related aid to one degree or another.

AVERAGE ANNUAL SHIPBUILDING AID BUDGETS OF TOP SUBSIDIZING OECD NATIONS SINCE 1988

Country	Ship Financing		Direct Yard Aid			R&D	Annual Average*
	Loans, Subsidized Interest	Guarantees	Contract Grants	Shipyard Capital*	Yard Loans, Interest Sub.		
S. KOREA	YES $1.8b	YES	Unknown	YES	YES $595m	YES	$2.4B
GERMANY	YES $1.5b	YES	YES $353m	YES $463m	YES Amt. unkwn	YES	$2.3B
JAPAN	YES $818m	YES	SOME	YES $85m	YES	YES $1b	$1.9B
ITALY	YES $557m	Unknown	YES $175m	YES $184m	Unknown	YES $24m	$940M
SPAIN	YES $306m	YES	YES $153.5m	YES $438m	YES	YES	$897M
FRANCE	YES $399m	YES	YES $149m	YES $83m	Unknown	YES $3m	$634M

**Excludes sums and subsidy values of government guarantees.*

Types of Foreign Shipbuilding Aid

Ship Financing Aid. The governments of top shipbuilding countries in Asia and the European Community provide (1) loans for ships built in the yards of their respective countries, (2) varying levels of aid to subsidize interest on loans, and (3) loan guarantee and export credit insurance. OECD countries who signed the Understanding on Export Credits for ships are supposed to adhere to the limits stated in that document--currently, 80% loans at 8% interest with 8½ years for repayment--but many schemes have been utilized to get around the limitations. Furthermore, there are no limits on ship financing for a shipowner who resides in a country designated as an LDC (lesser-developed country).

Contract Grants. Outright grants to shipyards for a percentage of a ship's contract price. This type of subsidy is used extensively by the governments within the European Community.

Shipyard Modernization, Reorganization, and Investment Aid. This type of aid to shipyards encompasses a wide range, from capital infusions (used extensively in Germany and to a lesser extent in Japan), to government purchases of outmoded facilities (Japan), to loans, interest assistance, and guarantees (used in both Europe and Asian shipbuilding countries, particularly in South Korea and Germany).

Ship/Shipbuilding R&D Aid. The true magnitude of government aid for the research and development of ship designs and ship manufacturing technology is difficult to uncover since it is one of the least transparent categories. Germany, for example, does not report specific projects to the OECD, while Japan consistently under-reports by hundreds of millions of dollars what it actually budgets.

EXAMPLES OF 1992 AND 1993 SUBSIDIZED CONTRACTS

Date/Country	Contract Details	Subsidy Details	Comments
Jan. 1993 ITALY	1 cruise ship, SUN PRINCESS (77,000 gt) *Price:* $300 million *Yard:* Fincantieri *Customer:* P&O Princess Cruises, Los Angeles	Subsidy: $117 mil. 9% contract subsidy 30% Italian flag subsidy	
Jan. 1993 ITALY	1 cruise ship (95,000 gt) *Price:* $400+ million *Yard:* Fincantieri *Customer:* Carnival Cruise Lines, Miami	Subsidy: $36 mil. + 9% contract subsidy	Sources at the yard put the real price of the ship at $550 mil., counting the contract subsidy and creative financing pckg.
Jan. 1993 FRANCE	2 cruise ships, option for 3rd *Price:* Approx. $333 mil. ea., $1 bil. for 3 *Yard:* Chantiers de l'Atlantique *Customer:* Royal Caribbean Cruise Lines, Miami	Subsidy: $90m+ ($30m ea) 9% contract subsidy (+ subsidy associated with financing package)	
Feb. 1993 GERMANY	2 containerships (1,066 teu) *Price:* Unknown *Yard:* Bremer Vulkan-MTW, Wismar *Customer:* Indonesian shipping	Subsidy: Not revealed, but eligible for 36% contract aid. Soft Loan: 85%, 12-years, at 4.25% interest	2/93 is date of EC Commission approval, despite objections of 2 European countries and shipbuilding groups.
Feb. 1993 SPAIN	10 multipurpose cargo vessels (6,500 dwt) *Price:* Unknown *Yards:* Santo Domingo (4), Vulcano (3), Freire (3) *Customer:* Nordane Shipping, Denmark	Soft Loan: Interest rate subsidy not revealed but estimated at 5 points, equivalent to 18% subsidy.	Subsidized financing arranged by Galician regional govt. through the centralized Official Credit Institute to get around the federal govt's decision to discontinue soft loans.
Jan. 1992 JAPAN	3 containerships (3,800 teu) *Price:* $375 mil., $125 mil. each *Yard:* Hitachi Zosen *Customer:* COSCO, China	Subsidy: $94.4m ($31.5m ea) 25.17% contract subsidy Soft loan: 89%, over 14 yrs., 8 yrs. grace, at 6% interest.	Subsidy provided to match German aid for COSCO ships, subsequently EC-disapproved.
Jan. 1992 FRANCE	1 roll-on/roll-off (ro-ro) vessel *Price:* $120.5 mil. *Yard:* Ateliers et Chantiers du Havre *Customer:* Undisclosed	Subsidy: $15.7m-$35.7m 13%-30%, see comments.	13% subsidy if France stayed within EC guidelines, but some reports claimed a 30% subsidy was granted to meet the Finnish competition.
Nov. 1992 GERMANY	4 containerships (3,765 teu) *Price:* $455.7 mil. ($114 mil. ea) *Yards:* Bremer Vulkan (3), HDW (1) *Customer:* COSCO, China	Subsidy: $43.3m ($14.4m ea) 9.5% contract subsidy (Govt. financing through KfW)	Original contract involving a 36% subsidy was disapproved by the EC.
Jan. 1992 SPAIN	5 containerships (36,500 dwt) *Price:* $380 mil ($76 mil ea) *Yard:* Astilleros Espanoles (AESA) *Customer:* TMM, Mexico	Subsidy: $104.5m ($20.9m ea) 27.5% contract subsidy Soft loan: 30 years, 14 yrs grace, 3.4% interest	The original deal was signed 1/92 with 5th ship added 3/92.

SUMMARY OF SHIPBUILDING AID PRACTICES IN:

FRANCE

GERMANY

ITALY

JAPAN

SOUTH KOREA

SPAIN

SHIPBUILDING SUBSIDIES: FRANCE

AVERAGE ANNUAL SHIPBUILDING AID BUDGET SINCE 1988 IN FRANCE

Ship Financing		Direct Yard Aid			R&D	**Annual Average
*Loans, Subsidized Interest	Guarantees	Contract Grants	Reorganization Aid	Yard Loans, Interest Sub.		
YES $399m	YES	YES $149m	YES $83m	Unknown	YES $3m	$634M

** Does not include loans for ships built for owners in lesser-developed countries.*
*** Excludes sums, subsidy value of government guarantees.*

DESCRIPTION OF SHIPYARD AID

- <u>Ship Financing</u>

Export Ship Financing and Guarantees - The French government provides loans for export ships at no less than 7.5% interest plus risk factor points to bring the rate into conformity with the terms of the OECD Understanding on Export Credits for Ships. In addition, the government provides loan guarantees in the form of export credit insurance.

Domestic Ship Financing - The Ministry for Maritime Affairs administers investment aid (grants) for the French merchant fleet up to 15 percent of the purchase price. Although the ships are not required to be built in France, it is not known if any vessels built outside of France have received the aid. In addition, the government is paying interest subsidies incurred before 1986 to domestic shipowners that ordered vessels built at French yards.

- <u>Direct Yard Aid</u>

The French government's budgetary allocations for its domestic shipbuilding industry can be used as ship production aid tied to specific contracts (contract grants) or as shipyard restructuring aid (shipyard capital).

Contract Grants - The French government may provide grants to French shipyards to enable them to win contracts up to the maximum level set by the Commission of the European Community. That ceiling was set at 28 percent for 1987-88, 26 percent for 1989, 20 percent for 1990, 13 percent for 1991, and 9 percent since 1992, with extensions granted so far through 1994. The government usually refuses to disclose specific subsidy amounts paid on individual contracts. (Fishing vessels are not subject to these ceilings.) As with other EC countries, aid paid to a French yard on a contract with a shipowner from a lesser developed country has no mandated ceiling.

Contract Grants for Chantiers de L'Atlantique. The primary recipient of French contract subsidies is Chantiers de L'Atlantique, the country's largest shipyard. Located in St. Nazaire, the yard is a wholly-owned subsidiary of GEC Alsthom, the French arm of a corporation formed by the merger of Alsthom Atlantique with the British company GEC in April 1990. GEC Alsthom, in turn, is 50 percent owned by the General Electric Company in Great Britain.

With the help of the French government, Chantiers de L'Atlantique has targeted the cruise ship and liquified natural gas (LNG) tanker construction markets in particular. "It is politically unacceptable for the yard to lose orders through the government's lack of subsidy,' however strapped for cash Paris may be," *Fairplay* Magazine said in its June 6, 1991, issue. That statement holds true today. All of the ships listed in the yard's current orderbook are subsidized cruise ships and LNG tankers. In addition, in 1992 Chantiers de L'Atlantique delivered the first cruise ships of the two-ship subsidized order for Kloster Cruise, and two ships for Royal Caribbean Cruise Lines--part of a subsidized four-ship order.

SHIPS ON ORDER AT CHANTIERS DE L'ATLANTIQUE AS OF JANUARY 1, 1993

Dates	Contract Details	Subsidies	Comments
Ordered: 2/91 Delivery dates: 4/94, 10/94, 6/95, 6/96, 6/97	5 LNG tankers, 130,000 m^3 *Price:* $1.3 bil, $260 mil ea *Customer:* Petronas, Malaysia	13-20% contract subsidy 13% = $169 mil ($33.8 mil ea) 20% = $260 mil ($52 mil ea) (plus govt. financing and any associated subsidy)	13% contract aid was the 1991 level; however, a spokesman for the French Ministry of Industry said that a 20% ceiling would apply because the order was negotiated in 1990. In addition, there is the fact that Malaysia is a lesser-developed country, so that no ceiling may have applied.
Ordered: 1/93 *Delivery dates:* 4/95, 4/96	2 cruise ships, option for 3rd *Price:* $1.3 bil, $333 mil ea *Customer:* Royal Caribbean Cruise Lines, Miami	9% contract subsidy $90 mil ($30 mil ea) (plus govt. financing and any associated subsidy)	
Ordered: 5/90 *Delivery date:* 6/93	Cruise ship, 2220 passenger (2nd of two-ship order) *Price:* $220 mil *Customer:* Kloster Cruises, Norway	20-40% contract subsidy 20% = $44 mil 40% = $88 mil (plus govt. financing and any associated subsidy)	20% subsidy would be within OECD guidelines. Govt. refused to confirm. There were reports that the subsidy was 40%.

Contract Subsidies for Atliers et Chantiers du Havre (ACH). ACH is a medium-sized yard that builds specialty ships, including the subsidized Wind Star Sail Cruise and Club Med cruise vessels. Its latest subsidized order is a $120.5 million roll-on/roll-off vessel. The subsidy amount is $15.7 million or $35.7 million, depending on whether the government stayed within the 13 percent subsidy ceiling or went to 30 percent in order to meet the Finnish competition, as was rumored. As usual, the government refused to disclose the subsidy details.

Shipyard Reorganization Aid - Most of the government aid in this category has gone to assist shipyard mergers and closures.

- Research and Development

In the area of government-aided research and development, French yards can benefit from the following: (1) subsidies to partially finance joint research operations with shipyards, (2) monetary advances administered by the Agence Nationale de Valorisation de la Recherche (ANVAR) to institute an innovation repayable only if the innovation is successful, and (3) programs supported by the Ministry of Industry to improve shipyard productivity, research specialization in sophisticated ships, and the improvement of basic knowledge to enhance shipyard competitiveness.

SHIPBUILDING SUBSIDIES: GERMANY

AVERAGE ANNUAL SHIPBUILDING AID BUDGET SINCE 1988 IN GERMANY

Ship Financing		Direct Yard Aid			R&D	*Annual Average
Loans, Subsidized Interest	Guarantees	Contract Grants	Shipyard Capital*	Yard Loans, Interest Sub.		
YES $1.5b	YES	YES $353m	YES $463m	YES Amt. unkwn	YES	$2.3B

**Excludes sums, subsidy value of government guarantees.*

BACKGROUND

The German government is currently administering a $4 billion aid package for the shipyards in former East Germany. The economic drain from this program has caused some government officials to attempt to cut back on cash grants to western German shipyards, but with little success.

The political clout of the German shipbuilding industry to retain government subsidies cannot be overestimated. Not only are shipyards important employers, shipyard-government political ties have been strengthened by the fact that the federal government and regional governments (Schleswig-Holstein, Bremen) have held, or continue to hold, equity stakes in some of the country's most important yards. The head of the largest shipbuilding group in Germany, Bremer Vulkan, was a Bremen senator for economic affairs when Bremen owned 26.1 percent of the conglomerate. The second largest German shipbuilding group, Howaldtswerke Deutsche Werft (HDW) is 75 percent owned by the federal government through a state steel mill and 23 percent owned by Schleswig-Holstein.

The German Association for Shipbuilding and Marine Technology (VSM), one of the chief lobbying groups for German shipbuilding subsidies, has tended to complain publicly that German shipbuilders do not get the top percentage of contract aid allowed in the European Community, but has been quiet on the fact that the industry gets generous financing help from the German state reconstruction bank, Kreditanstalt fuer Wiederaufbau (KfW).

DESCRIPTION OF SHIPYARD AID

- **Ship Financing**

Export/Domestic Ship Loans and Interest Subsidies - The German government bank KfW provides financing for export and domestic ships built in German shipyards, generally under the terms of the OECD Understanding for Export Ships. The government may subsidize the market interest rate by two percentage points for ships or as much as required to meet the conditions offered by foreign competitors. Ordinarily, KfW arranges the ship financing deals through the shipyards. It also arranges consortium financing involving public bank and private bank funds. In addition, KfW administers the 8E development assistance fund for financing loans and providing interest assistance to shipowners from lesser-developed countries. There are no restrictions on the amount of subsidy that can be provided under this program.

SHIP LOANS, INTEREST ASSISTANCE PROVIDED BY THE GERMAN GOVERNMENT

1988	1989	1990 (Incomplete)	1991 (Incomplete)
$1.76 billion	$1.8 billion	$1.3 billion	$1.1 billion

Guarantees/Insurance - KfW loans are insured by Hermes, with the federal government carrying the risk. Other guarantees may be provided by the governments of the four coastal states if they cannot be secured through ship mortgages.

- Direct Yard Aid

Contract Grants - The government pays German shipyards a percentage of a contract price of a ship in order for the yard to secure the contract. Since 1987, two-thirds of the contract aid is supposed to come from the federal government and one-third from the states. Although there have been notable exceptions, in general, the federal government has conformed to the following ceilings on contract aid for yards in western Germany: 20 percent, 1988 and 1989; 14 percent, 1990; 12.5 percent, 1991; west, 9.5 percent to mid-1992; 7.5 percent after mid-1992; east, 36 percent to 1994.

CONTRACT SUBSIDY BUDGETS (EXCLUDES 8E DEVELOPMENTAL ASSISTANCE)

Period, W. Yards	Budget	Period, E. Yards	Budget
1988 through 1990	$412m (dm700m) + $182m (dm300m) supplemental = $594m	1991 through 1993	$553m (dm830m)
1991 through 1992	dm 450m allocated = $294m (aid frozen for several months in 1991)		
1993 through 1995	dm700m ($467m) allocated = $467m (dm168m is for 1993)		

Development Aid/Tied Aid - The original purpose of development aid was to help out a lesser-developed country (LDC). However, since the mid-1980s, it has been a common practice in Germany to use funds from the KfW bank under the 8E program to attract business for domestic yards, particularly the government-supported conglomerates of Howaldtswerke Deutsche Werft (HDW) and Bremer Vulkan (BV).

Under the 8E program, a shipowner from an LDC gets soft loans for ships built at German yards on extremely favorable terms, and the German shipyard gets a generous grant that is not subject to any ceilings. For this reason, the German government agreed to call Israel an underdeveloped country in order to get two contracts for HDW to construct seven containerships which were delivered to Zim Israel in 1990, 1991, and 1992. During the late 1990s, China Ocean Shipping (COSCO) was also able to get cheap ships from subsidized HDW. Most recently, however, in a rare move, the Commission of the European Community decided the German government would be picking up too much of the bill on a tentative deal between COSCO and Bremer Vulkan and disapproved the plan, which would have paid a 33 percent subsidy to Bremer Vulkan and a 36 percent subsidy to Bremer Vulkan's recently acquired subsidiary, Mathias Thesan Werft (MTW) in former East Germany.

TIED-AID EXAMPLES BENEFITING HDW AND BREMER VULKAN SHIPYARDS

Customer/Dates	Yard	Ships/Price	Subsidy
Zim Israel, Israel *Order date*: 7/88 *Del. dates*: 4/90, 10/90, 4/91, 7/91	HDW	4 containerships 2,700 teu (46,700 dwt) Price: $228m ($57m ea)	*25.4% Grant* = $58m ($14.5m ea) *Soft Loan*: 100%, 10 yrs, 3.625% interest, 1 yr grace
Zim Israel, Israel *Order date*: 8/89 *Del. dates*: 1991, 1/92, 4/92	HDW	3 containerships 2,400 teu (46,700 dwt) Price: $167.4m ($55.8m ea)	*30% Grant* = $50.25m ($16.75m ea) *Soft Loan*: 100%, 10 yrs, 3.625% interest, 1 yr grace
COSCO, China *Order date*: 4/87 *Del. dates*: 10/89, 10/89, 9/90	HDW	3 containerships 2,700 teu 47,100 dwt Price: $166.8m ($55.6m ea)	*34.67% Grant* = $57.83m ($19.3m ea) *Soft Loan*: 100%, 15 yrs, 3.75% interest, 3 yrs grace
COSCO, China *MoA Date: 10/91* *EC DISAPPROVED, 7/92*	1)BV 2)BV-MTW	3 containerships 3,800 teu Price: $382.9m ($127.6m ea)	35% *Grant (Av.)* (36% MTW, 33% BV) = $134m ($44.67m ea) *Soft Loan*: 89%, 11 yrs, 3.5% interest

Currently, BV-MTW is under contract to build two 1,066 teu containerships for the Indonesian-flag company, which will receive a soft loan to cover 85 percent of the price over 12 years at an interest rate of 4.25 percent. The subsidy amount has not been revealed, but the yard is eligible to receive contract aid of 36 percent. The EC Commission, which approved the deal, has insisted that the shipowner must be a real resident of Indonesia and not just be using Indonesia as a flag of convenience.

During the past few years, the German government has paid subsidies to other German yards to build ships for firms flying the Indonesian flag, as well as owners flying the flag of Singapore, Turkey, the Cayman Islands, and others. German yards that have benefitted include J.J. Sietas and Meyer Werft. By the end of 1994, Meyer Werft will have delivered 15 passenger ferries to Indonesian owners, all of which have been subsidized by the German government. Subsidies have ranged from 29-39 percent with soft financing terms including 12-18 year loans at 3.25-3.75 percent interest.

Shipyard Capital - After February 1987, German regional governments were supposed to provide the aid for the rationalization, modernization, conversion, and diversification of shipyards within their respective boundaries instead of the federal government. Nevertheless, the federal government continued to provide this type of aid, in the form of loans, guarantees, and cash infusions for shipyard operations--primarily to government-owned HDW and Bremer Vulkan shipbuilding conglomerates.

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EXAMPLES OF SHIPYARD OPERATING AID TO HDW AND BREMER VULKAN

Year	Yards	Aid Amount	Aid Description
1987	HDW, BV	$83.4m (dm150m)	Federal/state injection of working capital.
1988	HDW	$63.9m (dm112.35)	Capital injection from govt.-owned Salzgitter.
1988	BV	$74m (dm130)	Credit guarantee.
1989	HDW	$22.6m (dm42.455)	Regional govt. (Schleswig Holstein) capital infusion.
1989	HDW	$2.6m (dm4.9m)	Shareholding capital and investment grants to take over the Flensburger yard. In addition, Schleswig Holstein provided state guarantees on loans for working capital and for future yields on the shareholding capital (unspecified amounts).

On July 20, 1992, the European Community (EC) approved the German government's plan to provide a $4 billion (dm6 billion) subsidy package to modernize, restructure, and cover the losses of the shipyards in former East Germany. The yards that are receiving the largest portions of the aid are the Norwegian shipbuilding conglomerate Kvaerner, which has taken over Warnow Werft, and Bremer Vulkan, which has taken over Mathias Thesan Werft (MTW). In exchange, Kvaerner will invest $71.3 million and BV $123 million in the yards. The following table shows the breakdown of the reorganizational aid.

EC-APPROVED SHIPYARD REORGANIZATIONAL AID ($4 BILLION TOTAL)

AID TYPE	Kvaerner - WarnowWft	BV -Mathias Thesan	Hegemann-Peene Wft	Volkswerft Stralsund	Elbewerft Boizenburg	Rosslauer Schiffswft
Investment	$325.3m	$251.7m	$92.5m	$187m	$6.8m	$08.5m
Restructuring	$379.7m	$351.67m	$65.9m	$81.5m	$18.1m	0
Closure (e.g., redundancy payments)	$ 46.7m	$24.8m	$21.5m	$25.7m	$11.0m	$07.3m
Losses, current contracts	$478.1m	$288.07m	$62.2m	$245.9m	$49.9m	$49.1m
Losses, old debts	$164.5m	$153.9m	$31.5m	$196.4m	$64.3m	$30.4m
New equity	$70m	$72m	$40m	$130.1m	$30.9m	$18.9m
Environmental	$16.8m	$42.3m	$0.8m	$1.3m	$0.13m	$0.2m
TOTALS	$1.5b	$1.2b	$314m	$868m	$181m	$114m

- **Research and Development**

The German government appears to be reluctant to reveal the scope of its involvement in subsidizing ship and shipbuilding-related R&D. Among the subsidized projects are: computer-controlled ship production techniques (through the Federal Ministry of Research and Technology and the Federal Ministry of Economics), and fast ferry R&D.

SHIPBUILDING SUBSIDIES: ITALY

AVERAGE ANNUAL SHIPBUILDING AID BUDGET SINCE 1988 IN ITALY

Ship Financing		Direct Yard Aid			R&D	**Annual Average
*Loans, Subsidized Interest	Guarantees	Contract Grants	Shipyard Capital	Loans		
YES $557m	YES	YES $175m	YES $184m	YES	YES $24m	$940M

**Does not include loans for ships built for owners in lesser-developed countries.*
***Excludes subsidy value of government guarantees.*

BACKGROUND

The principal commercial shipbuilding yards in Italy belong to the state-owned conglomerate, Fincantieri, which controls about 70 percent of Italian shipbuilding capacity. The yards are run at a loss, with the Italian government picking up the tab. Through the provision of substantial subsidies, the government has attracted orders to Fincantieri for sophisticated ships such as passenger vessels, thereby enabling the yard to develop the expertise that has established it as a market leader in a relatively short period of time.

DESCRIPTION OF SHIPYARD AID

- **Ship Financing**

Export Ship Financing - The Italian government may provide loans for export ships built in Italian yards through the Mediocredito Centrale bank. The government may also provide interest subsidies to bring the financing down to the rate of the OECD Understanding on Export Credits for Ships. In addition, export ships are eligible for export credit insurance, as are other capital goods, through SACE, a public agency.

Domestic Ship Financing - The Italian government provides interest subsidies for domestic ships to bridge the gap between available financing in Italy and the OECD rate for export ships. Orders can be placed in any EC country. When the vessel is maintained under the Italian flag, the amount of the government contribution is calculated on the basis of the reference rate plus two points. In addition, under the Finmare Law, Italian-built, Italian-flag ships can get 30 percent subsidies, which are equivalent to the depreciation on the vessels during the first five years. Another option is law no. 361/82, which allows for half-yearly subsidies on newly-built ships over 12 years, amounting to a discounted grant equivalent of 25 percent.

- **Direct Yard Aid**

Contract Grants - The government of Italy gives cash grants to Italian yards to enable them to capture contracts. Italy can provide the grants at the maximum level allowed by the Commission of the European Community. Since 1987, the percentage of a ship construction contract price that an Italian yard could receive was 28 percent (1987 and 1988), 26 percent (1989), 20 percent (1990), 13 percent (1991), and 9 percent (1992 through 1994, to date). Yards can elect to receive up to 75% of the grant at the start of construction, or at intervals during ship construction.

Between January 1987 and January 1990, Italian yards subsisted on a hefty backlog of orders placed in late 1986 to take advantage of the larger subsidy ceilings authorized until 1987. 1987 and 1988, contracts for 18 vessels were put on hold at Italian yards, waiting for action by Italian Parliament, which authorized the shipbuilding aid in early 1989.

Cruise Ship Contract Grants for Fincantieri. Of particular interest are the subsidies the Italian government pays to attract cruise ship contracts to the public shipyards of Fincantieri.

EXAMPLES OF CRUISE SHIP SUBSIDIES AT ITALY'S FINCANTIERI

Customer	Order Date	Ships/ Registry/U.S. Routes	Del. Date	Price and Subsidy
P&0, U.K. Princess Cruises, USA (Los Angeles)	1/93	<u>1 ship, 1,950 passenger</u> (77,000 gt) *Sun Princess* <u>Register</u>: Italy	1995	<u>Price</u>: $300m <u>Subsidy</u>: 9% grant = $ 27m 30% Italian flag sub. = <u>90m</u> Total: $117m (+ govt. finance)
Carnival Cruise, USA (Miami)	1/93	<u>1 ship, 1,300+ berths, 2,600 passenger</u> (95,000 gt) Foreign registry	1996	<u>Price</u>: $400m+ ($550m true cost) <u>Subsidy</u>: 9% grant = $36m (+ govt. finance)
Carnival Cruise Lines, USA (Miami) Holland America Lines subsidiary (Seattle)	1/89	<u>3 ships, 1,250 berths ea</u> (50,000 gt) *Statendam* *Maasdam* *Ryndam* <u>Register</u>: Bahamas <u>Routes</u>: U.S. West Coast, Alaska, Caribbean	 1992 1993 1994	<u>Price</u>: $200m 250-300m <u>300m</u> $ 750-800m total <u>Subsidy</u>: 28% grant = $210m-$224m (plus govt. financing subsidy)
Costa Cruise, Italy	7/89	<u>1 ship, 1,300 passengers</u> *Costa Classica* Italian flag To be marketed seasonally in North America Employed in Caribbean, Mediterranean	1992	<u>Price</u>: $270m <u>Subsidy</u>: 28% grant = $ 75.6m 30% Italian flag sub= <u>81.0m</u> Total: $156.6m
P&0, U.K. Princess Cruises, USA (Los Angeles)	1988	<u>2 ships, 1,700 passengers ea</u> (70,000 gt) *Crown Princess* *Regal Princess* <u>Register</u>: Italy <u>Routes</u>: U.S. West Coast, Caribbean	 1990 1991	<u>Price</u>: $275m ea, $550m total <u>Subsidy</u>: 28% grant = $154m 30% Italian flag sub = <u>165m</u> Total: $319m (+ govt. finance)

Until 1988, no cruise ships had been built at Fincantieri since 1966. In 1988, however, the Italian government made a deliberate attempt to use subsidies to capture cruise ship construction contracts for its public yards, starting with a contract with P&O-Princess Lines. Generous government subsidies enabled Fincantieri to become the world's premier cruise shipbuilder in just five years. Today, the Italian government continues to provide subsidies and cover Fincantieri's losses so that the shipbuilding conglomerate can remain internationally competitive in this market niche.

Shipyard Capital, Modernization and Reorganization - Italian shipbuilders can receive modernization aid (without increasing capacity) of up to 40 percent of the investment. Ship repair yards can be paid by the government for up to 80 percent of their investments. If yards reduce capacity by converting to other activities, they may receive government loans to cover 50 percent of the costs--70 percent for yards in the Mezzogiorno.

Shipyard Capital, Investment Aid - The Italian government routinely pays to cover the losses of state-owned Fincantieri, the commercial shipbuilding conglomerate which controls about 70 percent of Italian shipbuilding capacity. The yearly losses at these shipbuilding facilities are absorbed by the Italian government and approved by the European Commission. EC-approved loss compensation aid includes $106.5 million for 1988. (Figures were unavailable for 1989 losses, but they had been predicted to be greater than 1988.) EC-approved losses for 1990 amount to $224 million. Anticipated losses for 1991 were $145 million.

- <u>Research & Development</u>

The Italian government provides subsidies for ship R&D programs, covering up to 90 percent of the cost for research in ship design and ship propulsion, and up to 50 percent of the cost of building prototypes. This includes cruise ship R&D.

SHIPBUILDING SUBSIDIES: JAPAN

ANNUAL AVERAGE SHIPBUILDING AID BUDGETS SINCE 1988 IN JAPAN

Ship Financing		Direct Yard Aid			R&D	Annual Average*
Loans, Subsidized Interest	Guarantees	Contract Grants	Shipyard Capital*	Yard Loans, Interest Sub.		
YES $818m	YES	SOME	YES $85m	YES	YES $1b	$1.9B

**Excludes sums, subsidy value of government guarantees.*

BACKGROUND

Every aspect of shipbuilding policy in Japan is set and overseen by the government through the Japanese Ministry of Transport--to setting up cartels through the assignment of yards to shipbuilding groups, to deciding how much tonnage can be produced, to imposing guidelines on what shipyard improvements can be made, to controlling what facilities are disposed of, to influencing what kind of ships are designed and built, to recommending budgets for shipbuilding promotion and ship financing programs. By exercising such control over the industry, the government has played a significant role in the ability of Japan to be the world's premiere shipbuilding nation, with over 30 percent of the number of oceangoing commercial vessels on order and nearly 40 percent of the deadweight tonnage on order.

DESCRIPTION OF SHIPYARD AID

- Ship Financing

Export Ship Loans and Guarantees - Loans for Japanese-built export ships are available through the Japanese Export-Import Bank. Export insurance is underwritten by the Ministry of International Trade and Industry.

Domestic Ship Financing - There are two major programs available for financing Japanese flag ships:

Planned Shipbuilding Scheme (Keiku Zosen). The Ministry of Transport (MoT) provides 50-70 percent loans for Japanese oceangoing vessels through the Japanese Development Bank (JDB) at rates below prime with 13 years to pay, including a 3-year grace period. High-technology ships emphasized by the MoT (such as LNG tankers) get the best financing terms. The amount of financing disbursed from this fund has increased since 1989. The government has argued that the ships do not have to be built in Japanese yards; however, only one ship built outside of Japan has been financed under this program.

Maritime Credit Corporation (MCC). Special government-assisted financing and other benefits are available under this program for Japanese coastal vessels operated by domestic shipping lines and harbor transport companies.

KNOWN AMOUNTS OF JAPANESE GOVERNMENT SHIP FINANCING BUDGETS

	1988	1989	1990	1991
Ship Financing: (1) Export ship loans through Ex-Im Bank, (2) Loans for Japanese seagoing ships, (3) Financing for Japanese coastal vessels.	$849m	$733m	(Incl. proposed amounts) $826m	(Includes estimates) $867m

- <u>Direct Yard Aid</u>

Contract Grants - In general, the Japanese government prefers other methods of yard support. Currently, the government is providing a $94.4 million (25.17 percent) subsidy to Hitachi Zosen to build three 3,800 teu containerships for the China Ocean Shipping Co. (COSCO). Government support includes a soft loan covering 89 percent of the $375 million purchase price, to be repaid over 14 years at 6 percent interest with an 8-year grace period. The government defended the subsidy as a response to a German subsidy on COSCO contract. The German subsidy was subsequently disapproved by the European Community and withdrawn, but the Japanese did not follow suit.

Shipyard Çapital for Rationalization - For the period 1987 through 1991, the Japanese government budgeted $222.2 million to buy up redundant docks and facilities at Japanese yards and $370.4 million in government guarantees for debt payments for reorganizing or scrapping redundant docks-facilities, soft loans through the JDB, and a 10 percent tax exemption on capital investment for yards to convert to other industries.

Shipyard Capital for Modernization - The government also budgets aid to Japanese shipyards for the purchase of automated or high-efficiency machinery and equipment under the <u>Production Streamlining Program</u>. From 1987 to 1992, this budget was $41.1 million per year.

- <u>Ship and Shipbuilding Research and Development</u>

Japanese ship and shipbuilding-related research and development projects are often cooperative ventures between government institutions, government-supported universities, non-profit organizations set up to receive special grants, soft loans, and tax exemptions, and industry. The Japanese government budgets over $1 billion annually to support these programs. Current R&D projects supported with government funding include computer-aided manufacturing, environmentally-sensitive double-hulled tanker, high-speed Techno-Super Liner cargo ship, propellerless ship, advanced marine diesel engine, superconductive electromagnetic propulsion (Semp), ship hull weight reduction, improved shafts, hull coatings, noxious fumes reduction, and others.

Since July 1989, the Association for Structural Improvement of the Shipbuilding Industry (ASISI) has been the government entity responsible for promoting research and development in ship technologies and for granting subsidies to innovative marine R&D projects deemed too risky to be borne by private industry alone. This association replaced the Designated Shipbuilding Enterprises Stabilization Association. Government funding is distributed primarily through the Japan Shipbuilding Industry Foundation.

SHIPBUILDING SUBSIDIES: SOUTH KOREA

ANNUAL AVERAGE SHIPBUILDING AID BUDGETS SINCE 1988 IN S. KOREA

Ship Financing		Direct Yard Aid			R&D	*Annual Average
Loans, Subsidized Interest	Guarantees	Contract Grants	Shipyard Capital	Yard Loans, Interest Sub.		
YES $1.8b	YES	Unknown	YES	YES $595m	YES	$2.4B

**Excludes sums, subsidy value of government guarantees.*

BACKGROUND

South Korea became a world leader in commercial ship construction during the 1980s--second only to Japan--by offering rock bottom ship prices subsidized by the Korea Development Bank (KDB), thereby creating enormous debts, amounting to $4 billion by 1989 at the four major yards, an amount equal to four times their equity capital. KDB loans to shipyards remains a major component of South Korean shipbuilding aid.

In 1993, the Korean Ministry of Trade, Industry, and Resources announced a new five-year economic program in which shipbuilding is targeted for a 25.3 percent increase in gross tonnage (5.9 million gt) built at Korean yards by 1998, to include liquified natural gas (LNG) tankers, car ferries, and high-speed passenger vessels. As part of the plan, a 600,000 square meter industrial park in Pusan for ship machinery production is to be developed, utilizing a combination of private investment and government funds for industrial research and development.

DESCRIPTION OF SHIPYARD AID

- Ship Financing

South Korean state-controlled banks have become increasingly active in ship finance brokering, arranging loans with government and private Japanese banks for customers whose ships are built in Korean yards. Examples:

- In 1990, the Korea Development Bank arranged a lease finance scheme in which a bank consortium of the KDB, Korea Exchange Bank, and two private Japanese banks (Hanil and Sumitomo) provided a 12-year loan valued at $497 million to build five containerships for Hyundai and Hanjin at South Korean yards on financing terms more favorable than straight KDB financing.

- In March 1993, it was announced that the Korea Export-Import Bank was leading a consortium involving the bank and Japanese traders and bankers for financing the construction of a fourth 125,000 cubic meter LNG tanker at a South Korean yard (Hyundai Heavy Industries) to be operated by Hyundai Merchant Marine and hired out to the Korea Gas Corp.

Export Ship Loans and Guarantees - Government-supported financing for export ships built in South Korean yards is available through the Korean Export-Import Bank. Export ship financing guarantees are also available.

Domestic Ship Loans - Under the Government Financed Newbuilding Scheme (GFNS), loans are provided through the KDB for the construction of domestic ships in South Korean yards.

- <u>Direct Yard Support</u>

Shipyard Loans and Interest Subsidies - The Korean Development Bank has financed loans for shipyard working capital, equipment purchases, and technological improvements, since the government made the decision to build up the country's shipbuilding industry in the 1980s.

The Big Bailout. On August 28, 1989, the South Korean government approved a rescue package for Daewoo Shipbuilding and Heavy Machinery, the Korea Shipbuilding & Engineering Co. (KSEC), and Inchon Shipbuilding Co., consisting of interest-free loans, debt moratoriums, tax exemptions, and other benefits:

> *<u>For Daewoo</u>:* (1) A seven-year moratorium (until 1997) on $372.7 million of the yard's $2.1 billion debt. The interest savings alone is $208 million, which the yard has 17 years (until 2007) to repay the debt. (2) A new government loan of $223.6 million starting in 1990, to be repaid over 17 years, with a 7-year grace period (not interest-free). (3) A payment of $116 million from the government in 1990, and a payment from the Korean Ex-Im Bank of $200 million between July 1990 to 1995, to cover losses resulting from the 1984 contract default of U.S. Lines. (4) Exemptions from taxes and other legal restrictions on divestments and mergers.
>
> *<u>For KSEC</u>:* Tax cuts, easy loan terms, and other unspecified financial aid.
>
> *<u>For Inchon</u>:* Exemptions from certain capital investment restrictions.

- <u>Shipbuilding Research & Development</u>

In June 1990, the South Korean government announced that it was making $492 million available to major Korean shipbuilders and various Korean research bodies to develop ship design automation by 2001.

SHIPBUILDING SUBSIDIES: SPAIN

AVERAGE ANNUAL SHIPBUILDING AID BUDGET SINCE 1988 IN SPAIN

Ship Financing		Direct Yard Aid			R&D	**Annual Average
*Loans, Subsidized Interest	Guarantees	*Contract Grants	Operating, Reorg. Aid	Yard Loans, Interest Sub.		
YES $306m	YES	YES $153.5m	YES $438m	YES	YES	$897M

** Excludes financing, subsidies for owners in lesser-developed countries.*
***Excludes sums, subsidy value of guarantees*

BACKGROUND

The largest shipyards in Spain are government-owned (through the Instituto Nacional de Industria (INI), the sole shareholder) and are operated under the umbrella of Astilleros Espanoles SA (AESA). The government also owns the commercial shipbuilding yard Astilleros y Talleres del Noroeste (ASTANO), as well as the BAZAN naval shipbuilding yard.

Spain became part of the European Community (EC) in 1986. It was exempted from certain shipbuilding subsidy ceilings imposed the EC Commission, with the understanding that Spanish shipyards would make substantial cuts in shipbuilding capacity and be operating at profitable levels by 1991--something that has not yet been achieved. The Commission of the European Community had reported that $1.6 billion would be required to cover the losses of Spain's public shipyards for the four-year period 1987 through 1990. Yet the government does not admit to providing any shipyard operating or reorganization aid.

The true level of subsidization of Spanish yards is probably much higher than the estimates in the table. In 1991, the European Community Commission declared the $2.4 billion provided by the Spanish government in shipbuilding aid between 1987 and 1990 to be legal. However, how that money was allocated during the three-year period is not clear.

DESCRIPTION OF SHIPYARD AID

- Ship Financing

Export Ship Loans and Insurance - Ships can be built in Spanish yards with the aid of loans through the Banco Exterior de Espana and government subsidies to bring interest rates down to the 8 percent allowed under the OECD Understanding on Export Credits for Ships. OECD loans have been popular in Spain because shipowners could get the loans and invest the money at market interest rates of 13 percent. The Banco Exterior covers the risk of its loans. In addition, export credit insurance is available from the Compania Espanola de Creditor a la Exportacion.

In early 1992, the central government announced that it would not approve new government-backed soft export loans for ships. However, it appears that regional governments are willing to take up the slack, with the complicity of Spain's Official Credit Institute. In early

1993, for example, the Galician regional government has offered to back a loan to provide financing to three Spanish yards within its jurisdiction to help them win an order for ten multipurpose containerships for the Danish company, Nordane. The three yards are Santo Domingo, Freire, and Vulcano. The Galician regional government coordinated the loan with the Spanish Official Credit Institute, which is responsible for OECD-style loans.

Tied Aid - Subsidized financing, and contract grants are available from the Development Aid Fund without restrictions for the construction of ships in Spanish yards for owners from lesser-developed countries. Two examples follow:

EXAMPLES OF SPANISH TIED AID

Yard	Date	Customer	Contract	Govt. Subsidies
AESA	1992	TMM, Mexico	<u>5 containerships</u> (36,500 dwt) $380 mil.	<u>27.5% subsidy</u> = $104.5 mil. <u>Soft loan</u>: 30-yrs, 14-yr grace period, 3.4% interest
AESA-Vigo	1991	Lignes Maritimes du Detroit, Morocco	<u>Ferry</u> Price undisclosed	<u>30% subsidy</u> <u>Soft loan</u>: 30-yrs, 10-yr grace period, 2% interest

Domestic Ship Financing - The state Industrial Credit Bank provides 85 percent loans for new ships built for Spanish owners at 8 percent interest, with 12-14 years to repay and a grace period of up to 2 years. Interest subsidies are provided up to three points.

- <u>Direct Yard Aid</u>

Contract Grants - The Spanish government gives a combination of contract-related grants for new ships and ship conversions, comprised of a production grant and a special grant, both of which vary and are based on a percentage of contract value. <u>Production grant</u> ceilings imposed by the Spanish government vary with the value of the contract and go up to 23 percent, with the higher value new construction contracts eligible for the higher subsidies. The <u>specific grant</u> is in addition to the production grant and has a ceiling of 5 percent of the contract value.

Shipyard Operating, Reorganization Aid - The Spanish government does not admit to providing shipyard operating and reorganization aid. Nevertheless, the government covers the losses of the public shipyards each year. AESA, the largest public shipbuilding group, lost $95 million in 1992, $49.2 million in 1991, $102.6 million in 1990, and $142.2 million in 1989.

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SHIPBUILDING AND SHIPBUILDING MANAGEMENT, 1943–1993

One Man's Perspective

Lloyd Bergeson, Member, Shipbuilder (Ret.)

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9-21 - verbal approval to Carl Bentzel

Even as many wonderful ships have been conceived and built, over the last fifty years there have been major advances and regressions both in shipbuilding volume and in the art and science of applied ship design and construction management. External factors affecting shipbuilding included the crucible of WWII; the Cold War; wavering national maritime policy and practice; the shift of commercial shipbuilding's focal point from west to east; the withering of the Maritime Administration's technical abilities; erratic, more political and less effective naval ship procurement practices; general relaxing of moral and ethical standards in both business and government; the "Bottom Line Syndrome"; and, finally, environmental considerations exemplified by the Oil Pollution Act of 1990 and aspects of global warming. Within shipyards and absent undue external influences, success has been in large measure equated to consistent application of fundamental management principles and practices. Failures can generally be equated to the convergence of one or more negative external factors with failures within the corporate organizations responsible for the management of the shipyards. The overall panorama and a number of individual cases within it are reviewed from the perspective of one whose principal goal and profession over the past five decades has been the optimization of the shipbuilding process and the management thereof.

THE WORLD WAR II SHIPBUILDING ACHIEVEMENT, 1940–1945

"From modest prewar proportions the shipbuilding industry of the United States grew to gigantic size under the unremitting pressure of war demands. During the war the industry's functions and objectives were clearly defined. The construction of the greatest naval and merchant marine the world has ever seen, all within the space of five swiftly moving years, is the best possible demonstration of how well the industry has performed its war functions and attained its war objectives."

– E. L. Cochrane, VAdm USN, Chief, Bu. of Ships
– E. S. Land, Chairman, U.S. Maritime Commission

Summary

The year 1943, the 50th anniversary of the founding of our Society, proved also to be the climactic year in the history of U.S. shipbuilding: 1896 merchant vessels totaling 13 million gross tons and 18,294 naval vessels totaling 2,586,000 displacement tons were delivered from U.S. shipyards and put into war service. A peak of 2 million men and women were engaged in the shipbuilding, ship repair and overhaul effort during that year.

Included in the above new construction totals for 1943 were 1661 commercial vessels of 2000 gross tons or over and 540 naval vessels of 1000 light displacement tons or over. These came from the ways or building basins of 82 private shipyards, 15 of them created subsequent to 1940, and 8 naval shipyards. The rest came from hundreds of boat yards, yacht yards, barge builders and fabrication plants of all categories.

Only four years previously – in 1939 – and with the war approaching, 24 private yards and 8 naval shipyards delivered only 28 merchant ships totaling 242,000 gross tons and 27 naval vessels totaling 66,000 displacement tons.

1943 was to prove the all-time peak. Deliveries of merchant vessels over 2,000 gross tons were in 1944 down by 12 percent due in part to a shortage of steel. In 1945 they were down from the peak by 22.5 percent and in 1946 by 95 percent. With only 83 ships delivered, naval vessels of 1000 displacement tons and over dropped from the 1943 peak by 15 percent in 1944, 31 percent in 1945 and 85 percent in 1946 when 78 vessels were delivered.

The composition by type of the major combat and naval ships and auxiliary naval vessels delivered in the total period 1940–1945 is tabulated below. The statistics do not include U.S flag ships sunk during the war or those built for or transferred to Allied countries.

Combatant Ships	
Battleships	10
Aircraft Carriers	31
Destroyers	397
Submarines	223
Mine Layers	13
High Speed Transports	56
Destroyer Escorts	505
Aircraft Carrier Escorts	102
Frigates	96
Total	1482

TABLE OF CONTENTS

c

Auxiliary Naval Vessels

MTBs Tenders	4
Ammunition Ships	3
Landing Ship-Vehicles	4
Submarine Rescue Vessels	5
Submarine Tenders	5
Repair Ships	4
Seaplane Tenders	39
Destroyer Tenders	8
Total	72
	1554

These were delivered from 39 private yards (24 existing and 15 new or reactivated and 8 naval shipyards).

The composition by type of merchant and other vessels constructed under contract to the Maritime Commission in the period 1939–1945 is summarized as follows

Standard cargo (C-1, 2, 3, & 4)	541
Emergency cargo (Liberty)	2708
VICTORY cargo	414
Tanker [T-2 & 3]	595
Other types	110
Minor ship types (less than 2000 GT)	727
Military types	682
Total	5777

The minor and military ship types totals probably include 27 LSDs and some aircraft carrier escorts not included in the combatant ship count, as well as 50 troop ships, 96 escort vessels (Corvettes), 50 troop ships, 60 cargo attack ships, 50 tank carriers, 117 VC2-5 APS transports, LSTs, 20 P2 (10,000T) troop transports, plus the following categories naval oilers, coastal tankers, and hospital transports

The countless other naval ships constructed in the period 1939–1945 were divided into several major categories These and the ship types within each category are listed and the numbers of facilities producing them are summarized in Table 1.

Major vessels (2000 gross tons or 1000 displacement tons or over) were built in 23 states on all three coasts East, West and Gulf, as well as all navigable rivers and the Great Lakes The manufacture of the smaller craft undoubtedly involved all 48 states.

Forty shipyards were devoted to the repair and overhaul of naval and commercial ships during the war years.

Year	Ships Overhauled
1942	5,158
1943	17,172
1944	22,014
1945	23,558

Deliveries of steel for merchant ships alone went from zero in 1935 to peaks of 13.3 million tons in 1942 and 12 million tons in 1943.

By 1945, total shipyard employment had dropped to 224,000 persons. In that year only 4 merchant vessels and 8 naval ships were delivered. The wartime contracts had been completed and the market for the commercial and naval ships had been saturated!

The state of the art of the shipbuilding business in the U.S.A as achieved in the wartime years (1940–45) was captured in a two-volume book of the same name in 1948 edited by Professor F.G. Fassett and published by the Society [1]. This book (SBUS) was sponsored by the then-current President of the Society, E.L. Cochrane and six past presidents of the Society – H.L. Ferguson, J. W. Powell, H. Gerrish Smith, Emory Scott Land and J. F. Metten [It was my great privilege to know all of them except Homer Ferguson!] Its authors include William Blewett, President of Newport News during the war, and later president of the society It covers all aspects, principles and procedures involved in the business of building and repairing seagoing ships It is the source of much of the background information on the WWII effort in this and later sections of this chapter Since fundamental principals have not changed it is a firm "benchmark" from which to measure developments both good and bad in the state of the art of shipbuilding in the nearly five decades since it was written

Table 1. Other Naval Ships

Landing Craft (Navy records show that 75,113 were built)

Major types:

- 14 types ranging from 112 to 4,500 tons displacement, including 1,026 LSTs of 1,626 L.T. (390 of these were built under MARCOM contract); 31 private shipyards and 6 naval shipyards were involved

Minor types:

- In 1944 alone, 25,171 landing craft of less than 50 tons were produced There were innumerable types, some as small as 0.05 tons displacment.
- 68 yacht and boat yards, plus various other facilities produced these craft.

Small, Self-Propelled Naval Vessels (auxiliary and combatant/less than 1,000 displaced tons)

- Harbor and fleet tugs, sub chasers, mine sweepers, coastal transports, motor torpedo boats, patrol craft, salvage vessels, net layers, utility boats, gunboats, gunships
- 106 yacht yards, boat yards, large builders, and private shipyards, plus 7 naval shipyards contributed

Barges, Buoy Boats, & Small Craft (7–400 Tons)

- Aircraft rescue boats, barges of all types, buoy boats, ferrys
- 106 barge builders, shipyards, yacht, & boatyards, plus 7 naval shipyards were involved.

Small Boats, Lighters, etc. (up to 750 displacement tons)

- Picket boats and launches, lighters, ship's & whale boats, wherries, dinghies & prams (8'!), plane rearming launches and boats, personnel boats & water taxis, life rafts & inflatables, submarine salvage pontoons, seaplane derrick boats, car and other floats, gate vessels, diving tenders
- 166 shipyards, boatyards, barge builders, boiler shops, iron works, and 8 naval shipyards participated

Coast Guard Vessels

- Tenders to 230', cutters to 256', tow boats, ice breakers to 239', barges, and tugs.
- 11 yards participated, including the Coast Guard yard at Curtis Bay, MD.

War Department Vessels

- Tugs, self- & non-propelled boats, barges & floating cranes.
- 224 shipyards, fabrication shops, iron works, bridge companies, yacht builders, boiler works, welding companies, and other facilities were involved

Evaluation

Looking back from a perspective of 50 years, it is incredible, even to one who was fully involved in the naval shipbuilding effort from 1940 through 1945, that the entire program could have been conceived, planned, engineered and executed in a period of six years. Indeed it could not have been without the head start, tiny though it was, provided by the Merchant Marine Act of 1936 on the one hand and the small prewar naval shipbuilding program on the other – both very much sponsored by Franklin D. Roosevelt.

Then in 1938 Roosevelt assured that the goals of the Merchant Marine Act would be professionally and brilliantly executed by appointing VAdm Emory S Land, USN (Ret) first as a commissioner and then almost immediately as chairman of the Maritime Commission – when Joseph P Kennedy surrendered the office on being appointed Ambassador to Great Britain In June 1940 RAdm S M Robinson was appointed as Chief of the Navy's Bureau of Ships, which resulted from the long-overdue consolidation of the Bureau of Construction and Repair and the Bureau of Engineering In November 1942, Robinson was appointed Chief of Naval Material RAdm E L. Cochrane succeeded him as Chief of the Bureau of Ships with RAdm Earle W Mills as his assistant While Robinson had assumed command of the world's greatest technical organization of the time, Land, from a standing start in 1938, built a technical and administrative organization capable, under the direction of himself and his deputy ADM Vickery, of incisively directing the wartime merchant shipbuilding effort It is an outstanding case history in the art/science of good management Pick the right leaders, give them goals, provide support, and let them work out the solution Then monitor the work and criticize, but constructively, and then help when the need becomes apparent! It was that approach that Robinson, Cochrane, Land and Vickery, in partnership, followed consistently with both the established shipyards and the variegated entrepreneurs who were to be entrusted with the direct management of the construction of the tremendous variety of new vessels which were required in such large quantities It is a saga of epic proportions

As the product of the wartime shipbuilding effort, there were by war's end (September 1945) 5529 U S -flag vessels in commission representing 54 percent of the world's merchant fleet and 62 percent of the world's dead-weight tonnage This compared with but 18 and 20 percent respectively in 1939 And it is important to note that ADMs Land and Vickery had, despite the heat of battle, made sure that that fleet was largely made up of the world's most advanced merchant ships and tankers – most of them designed under the Maritime Commission's auspices.

WWII Shipyard Layouts

SBUS describes the layouts of three major "standard" private yards Newport News, Quincy and New York Ship, which were operational at the start of WWII The yards were suitable for and engaged in the design and construction of a variety of major combatant ships – battleships, carriers, heavy and light cruisers and a peacetime residue of passenger and cargo liners All three of the yards had originally been engineered and built at the start of the 20th century and then expanded and improved in WWI and at the start of WWII The New York Ship yard is, perhaps the most remarkable by virtue of its brilliantly conceived crane transfer system and high-capacity cranes specifically provided to allow planned preassembly of structural units up to 300 tons This was at a time when 5- to 10-ton bridge cranes over building berths were the accepted norm The original five ways and the adjacent wet basin were all under a permanent roof All three yards originally launched from inclined ways Newport News, Quincy, and New York added two building basins of the semi-submerged type at the start of or during WWII

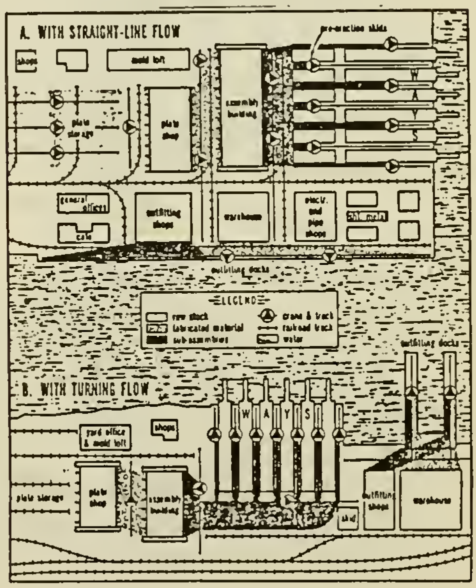
These "standard" yards had extensive manufacturing facilities They could and did manufacture and assemble their own turrets, boilers, turbines, gears, condensers and other heat exchangers, pumps, valves and other ship components In addition they had their own ferrous and nonferrous foundries Several naval shipyards, including Boston, New York, Brooklyn, and Norfolk, had similarly versatile facilities There were two other major yards, Federal, in Kearny, New Jersey, and Sun Shipbuilding and Dry Dock Co., at the start of the war The former was engaged in multiple production of like naval ships, the latter was engaged in building several series of tankers for its parent and other oil companies

Since the above yards were fully engaged at the start of WWII, the war demand for large numbers of a variety of ship types to be built in serial production required the creation of new yards with multiple production of one ship type as a major criterion rather than versatility Thus most of the emergency yards that were created for both the maritime commission and naval shipbuilding programs were set up for either straight-line flow or angled flow from steel storage through fabrication, preassembly, unit assembly and finally erection or outfitting on the ways or in a level building berth (See Figure 1 below)

A precedent for the WWII multiple production yards had been set in WWI, notably by the Hog Island yard layout and preplanned fabrication scheme, the Squantum, Massachusetts, destroyer plant managed by Bethlehem, and the River Rouge Plant of the Ford Motor Co for the production of Eagle Boats The latter, predictably, was a land-level-progression-type yard with one hydraulic lift dock for launching

Several of the new yards to build LSTs for the Navy were excellent examples of "progression" type assembly and preinstallation lines, notably, the Chicago Bridge and Iron plant in Seneca, Illinois, and the American Bridge plant at Ambridge, Pennsylvania The Dravo yard above Pittsburgh and their plant in Wilmington, Deleware, progressed the hull construction of corvettes laterally through four stations to a side-launch position The Jeffersonville Boat plant progressed construction longitudinally above the river bank to a side-launch position In

Figure 1. Layouts of shipyards for multiple production



1943 alone over 15,000 landing craft of under 50 tons were produced on assembly lines throughout the United States. Besides LSTs and Corvettes, other substantial vessels on the order of 1000 displaced tons were built on assembly lines. These included coastal cargo vessels, coastal tankers and tugs.

In 1942 Andrew Jackson Higgins of New Orleans succeeded in obtaining Maritime Commission authorization for a "44 Way Equivalent" yard for Liberty Ship production, "equivalent" because it would have that many ships under construction simultaneously. It was to have four parallel assembly lines [2 pairs of 2 adjacent lines] one mile long on which platforms for the ships would move down an incline. Construction would start with the amidship machinery spaces at the head of the line into which the engines, boilers and the rest of the outfitting materials would be incorporated. At each subsequent station designated hull sections, also preoutfitted, would be added. Fabrication and assembly shops were to be suitably arranged on either side of and between the two pairs of lines. One pair of lines was to be completely manned by whites and the other completely manned by blacks. This yard was cancelled out because of a perceived steel shortage on the part of the War Production Board in 1942. Bold in concept, it would undoubtedly have been a spectacular success if from the outset preplanning of the prerequisites to the work on the final assembly line had been executed with absolute precision. But the basic strength of a production line is also the basic weakness for a product as complex as even the relatively simple WWII merchant ships. Lack of just one part, assembly, pump or valve can not only disrupt the line but completely shut down production. This is not true in yards employing building berths where material shortages can create less dramatic (nearly invisible) but sometimes more serious delays and cost overruns along the critical path[1]

In the WWII yards the platen assembly storage areas and ways were almost universally serviced by whirly cranes ranging in capacity from 5 to no more than 50 tons. New York Ship in Camden, New Jersey, also had turning flow, using bridge cranes over both assembly areas and the ways. Across the river the reopened Cramp yard had a storage yard, a fab shop and assembly areas and the heads of the ways all serviced by bridge cranes traversing the lot (3 bays in all) with shipway bridge cranes passing over them at right angles. The assembly platens thus were of quite adequate area.

All of the multiple or serial production yards dedicated individual bays to the progressive fabrication manufacture of like items and in many cases the progressive buildup of welded subassemblies.

Lane has noted that the early Liberty shipyards had straight-line flow but were severely hampered because inadequate areas had been planned for preassembly and storage of preassemblies ahead of the ways. I must state that this discrepancy stemmed in part from an unperceived (at the time) defect in my MIT college thesis of 1938 – "The Layout of a Shipyard for the Serial Production of All-Welded Ships." I had been encouraged by the Bath Iron Works to make this pioneering effort (the first such layout of record, I am told) when I worked there the summers of 1936 and 1937. Then when Henry J. Kaiser got involved in the Liberty ship effort, A. M. Main, Sr. at Bath referred him to my thesis as a model. Kaiser's facilities people copied it! I realized the discrepancy in my work as soon as I arrived at Cramp in the fall of 1940 and started to plan the use of that facility for the cruisers, but by then the Kaiser yard layouts were literally cast in concrete. Henry J. Kaiser, a charming man when he wanted to be, never seemed to hold it against me when we often met during the course of the war.

WWII Process Advances

All-Welded Ships

The greatest WWII advance in process technology involved the use of arc welding to largely supplant riveting. Prewar pioneers in developing welding for ships included the Electric Boat Co. (EB) in Groton, Connecticut, for submarine construction and Sun Shipbuilding and Dry Dock Co. in Chester, Pennsylvania, for tanker construction.

EB is credited with building the first all-welded, self-propelled vessel in the U.S. – their yard tug – in 1928. This vessel is still in service. In the prewar years they increasingly applied welding to submarine construction and by WWII riveting had been entirely eliminated therefrom.

At Sun, according to Merville Willis, John G. Pew, Sun's president, in collaboration with Lester Goldsmith, the chief engineer of one of their important tanker customers, Atlantic Refining, developed what could be called the world's first automated panel line. They devised a series of jacks on an overhead strongback which made a tight joint between a stiffener and a single plate. All stiffeners on a single plate were manually tacked in place. The plate, with its stiffeners, was placed in a tilting table and rotated 45 degrees so that both the plate and one stiffener side were inclined to make a downward-pointed vee. One side of the stiffener was then welded to the plate by a mechanically propelled, submerged arc, Unionmelt welding head. This head made a fillet in one pass in the true downhand position. After the fillet was made on one side of all stiffeners the table was tilted 90 degrees and the process was repeated on the other side. When all stiffeners were attached to all plates of one section, two adjacent plates were placed edge to edge under the jacking arrangement. The plate edges were clamped in place and another mechanically propelled Unionmelt head made a single-pass, full-penetration weld of the seam. The unit was then moved to put the next seam under the jacks and the weld was repeated. Upon completion of the seam welds the entire unit was pulled by a winch onto a table where the transverse stiffeners were fitted and welded manually. The complete unit was then turned over, the seams finished off with portable Unionmelt heads, and the edges trimmed to remove any excess material left on the edges to allow for plate contraction due to welding. Sun had seven of these assembly lines, of which two were used until the mid-1960s.

Messers. Pew and Goldsmith first used their new process in welding the midbody panels of the J. W. VAN DYKE, a 13,000 DWT tanker completed in 1938 (The VAN DYKE also, of course, employed Goldsmith's advanced ideas with respect to HP/HT steam conditions and electric drive.)

The Unionmelt process using portable tracks became a mainstay of production for seam and butt welding and in manufacturing stiffened panels and was in almost every WWII shipyard building commercial and naval ships.

Down in Pascagoula, Mississippi, in the meantime, Bob Ingalls had undertaken to build C-3s to George Sharp's design in his newly established yard. In reviewing the plans provided by Sharp for the first C-3, EXCHEQUER, my MIT classmate John G. Lord discovered in the fall of 1939 that some of the structural detail around the hatches called for riveting. Ingalls had the welding engineers devise procedures to plug-weld the rivet holes and was then able, when he delivered it on November 1, 1940, to claim credit for delivering the first all-welded ship completed under the Maritime Commission program.

On naval surface ships, the switch to welding was more conservatively carried out than in the merchant ship program

Riveting was retained on seams of the larger ships throughout the war, and great attention was paid to erection and welding sequence to avoid "locked up stresses." The writer remembers his anxiety with respect thereto during the construction of six light cruisers at Cramps, after having prepared in the fall of 1940 the sequences and procedures actually used! (There were no failures!)

But in the first quarter of 1943 and continuing into 1944 there were a series of catastrophic failures in the hulls of all-welded merchant ships – all of them involving dramatic fractures across the ship and down the sides. They involved several classes of ships. There were 25 complete fractures, and eight ships were lost at sea as a result. Most failures occurred in cold weather. An ad hoc committee of "experts" suggested various immediate remedies, including the elimination of obvious "notches" and other stress raisers in the sheer strake and bulwarks, providing riveted "crack stopper" plating around hatches and other deck discontinuities, and renewed attention to welding sequences, as well as the avoidance of the use of Unionmelt. (!) Ultimately, after some high-priority R&D, the solution was found to be simple and straightforward. It was to avoid obvious stress raisers in the way of structural discontinuities and develop steel that was not notch sensitive within the temperature range of ship operation. It was found that "locked in stresses did not contribute materially to the failure of all-welded ships." (So much for my worries on the subject!) Nor was the use of Unionmelt found to be a culprit. From an "Olympian" viewpoint there were only 25 such failures out of 4,694 welded ships. Ordinary prudence and common sense by the builders had prevailed in all but the statistically insignificant number of cases. Nevertheless the 25 failures were dramatic. It is a certainty that the WWII shipbuilding program could not have been realized without the extensive use of arc welding to replace riveting on naval ships and its almost exclusive use on the merchant-type vessels build in the "multiple" yards. That this successful conversion to welding from riveting was accomplished with such success is nothing short of miraculous.

Hull Modules and Preoutfitting

We have already noted that in 1899 New York Shipbuilding Corporation made modular construction a basic criterion in the design of their new yard. But as welding became prevalent in ship construction during WWII, it enhanced in all yards the practicability of building the ship hulls in modular fashion up to the limits of crane capacities. If the modules were preplanned and comprehensive, their use could dramatically reduce the time that a given ship tied up a particular way or building berth. If preoutfitting of the modules was also rigorously planned and executed, the time in the outfitting basin could also be substantially reduced. Thus greater throughput was possible from a given number of building berths. All of this was to say nothing of the potential for significant reduction in man-hours required for installations.

On combatant ships more and more preassembly of inner bottom assemblies, cofferdams, bulkheads, deck and superstructure assemblies, bow and stern assemblies was planned in the various shipyards. The first preoutfitting that the writer knows of was at Newport News early in the war where it started the logical process of installing all piping and heating coils in inner hull assemblies of light cruisers before incorporating the closing inner bottom plating. When the writer attempted to introduce this practice on sister ships being built at reopened Cramp Shipbuilding Co., in Philadelphia, it was met with massive resistance in the yard. I therefore arranged a modest and clandestine experiment designed to install the piping in a preassembled coffer dam of a light cruiser that was called for in the machinery spaces (at bulkhead 101, I remember!) while it was flat on the platens and before the closing plates were welded in place and the unit was erected. The work was accomplished on the second shift. The pipeshop's "Pappy" Grandahl was of the old school and was the stoutest resister within the yard's management planning and any such nonsense as preoutfitting. But he kept excellent records of man-hours by each job. When the returned man-hours for the job passed over his desk he noted that it had taken 40 hours as opposed to 400 hours on the previous job. The quarterman, when queried, correctly reported that the dramatic decrease was the result of preplanning. Grandahl turned 180 degrees in direction overnight and became the most forthright and vocal champion of systematic planning and production control in the shipyard; a major victory in the effort to apply "scientific" management to ship construction at that yard.

About that time Cramp received an order for 10 fleet-type submarines to be built to Portsmouth Naval Shipyard plans, later increased to 20. These seemed like ideal candidates for modular construction and extensive preoutfitting. They had a long, cylindrical inner hull around which were wrapped the ballast tanks, the outer plating of which formed the "shaped" outer surface of the submarine. Working in concert with LT Henry A. Arnold at the Portsmouth yard, we jointly developed this modularization and preoutfitting concept for both of the yards. It required but modest design changes to implement the approach fully. We installed all foundations, bulkhead penetrations, sea connections and valves including ballast blow and vent valves; also wireways, pipe hangers and equipment where available. The effort was highly successful in cutting down the time required on the ways in each of the two yards, and for Cramp in reducing anticipated man-hours both for hull construction and installations – since we were in a yard "start-up" phase.

The Cramp effort to deliver the submarines on schedule was unfortunately precluded by circumstances beyond our control. We were the last yard into the program and engines were in short supply. We suffered three changes in the make of engine to be installed within the first six months of the contract and then did not get any at all! Bad as this was, the Bureau of Ships "inexcusably" directed us to subcontract the manufacture of the torpedo tubes to the Kohler (bathtub!) Company even though we had a fully equipped machine shop and the know-how to manufacture them. By the time we had reassumed responsibility to manufacture the tubes it was time to launch the first pair of submarines. Fortunately we were able to borrow from Portsmouth a set of engines and a set of tubes for the first ship before we launched it. The other nine vessels were launched without engines or torpedo tubes. Fitting torpedo tubes into place when a submarine is in the water required ballasting, to bring the opening up out of water, and other heroics. We accomplished them, but I do not remember our receiving any medals or citations therefor.

Postwar, I was able to compare the man-hours and learning curves of Cramp, Portsmouth and Electric Boat. EB of course had built their entire wartime program of 90 submarines piece by piece over each of twenty ways. EB's hours had come asymptotic to 1,200,000 at about the 40th or 50th ship. At Cramp the way time was drastically reduced and Cramp's man-hours had come asymptotic to a slightly higher figure at about the ninth or tenth ship. This was a powerful endorsement not only of modular construction and preoutfitting but also of the rigorous preplanning· controlled dispatching of the work.

and its inspection and sign-off before releasing dependent work, which we had introduced at Cramp.

The modest successes described above are merely illustrative of the enormous advances in the state of the art of shipbuilding made possible throughout the instantly burgeoned industry by the war's insatiable demand for ever more ships to "impossible" schedules. These advances were achieved throughout the massive countrywide program wherever and whenever innovation and traditional know-how were successfully integrated to seek out, engineer and implement improvements in the process. Multiplied thousands of times over, they helped create the ship production miracle of WWII.

Development of Shipyard Management Systems Through WWII

The well designed ship is always an object of great functional beauty–a true compendium of art, the latest developments in science, technology, and plain hard work. Thus the successful building of great ships down through centuries has always required the timely sequencing and coordination of myriads of interdependent details; no single element, no matter how important, being sufficient unto itself. Planning and program management had to have been a way of life for the master shipbuilder who produced the great Viking "GODSTAD" ship, circa A.D. 800.

Traditionally in smaller shipyards the management system consisted of what was in the head of the yard manager – directly transmitted by him to his subordinates on a daily basis. This was the highly successful approach, born of the economic necessity and suited to his encyclopedic shipbuilding know-how and particular genius, employed by W. S. Newell at Bath as he rebuilt it from an abandoned shipyard in 1928 to a position of leadership in destroyer production in WWII. Until the war, there was no central planning department, other than Pete Newell. The planning for construction was in each shop either in the heads of or under the direction of the individual foremen.

The concept of organized systematic central planning and production control in manufacturing developed starting shortly before the turn of the century as an element in the drive to increase the productivity of individual workers. The towering leader of this drive was Fredrick W. Taylor, whose papers entitled "The Principles of Scientific Management" [2] and "Shop Management" [1903] and finally the "Art of Cutting Metals [1906] each created a sensation when presented before the Society of Mechanical Engineers. The principal objective in this new industrial engineering movement was to improve the productivity of each worker to the limit of his intrinsic capability and to reward him accordingly. (Hence incentive system.) Taylor also was to first identify the principle of "management by exception" that preplanning made possible. Rigorous planning became a "must" for the successful construction to tight schedules of ever-more complex fighting ships in WWII and thereafter.

The larger yards described under section III tried to develop these planning principles and organize for them with varying degrees of success. As late as 1941 in one large naval shipyard, communications between department heads and the central planning department were accomplished by wrapping memorandums around bricks and throwing them through the glass transoms of the planning department offices!

We have previously noted the SNAME-sponsored book, *The Shipbuilding Business in the USA* (SBUS) [1]. It authoritatively describes the full range of management practices in WWII, as illustrated in the following list of pertinent chapter titles:

- Shipyard Organization
- Labor in Shipbuilding
- Shipyard Wage Systems
- Proposals & Contracts
- Planning, Designing & Scheduling
- Cost Estimating Procedures
- Production & Material Control
- Procurement & Storekeeping
- Corporate Accounting Management & Control
- Cost Assessment & Cost Accounting
- Inspection & Guarantees
- Comparison of Shipbuilding & Ship Repairing

The chapter on production and material control describes the Newport News Group System. Its genesis is described below because in the fifty years since WWII advances in the art of scientific management in shipyards can be directly linked to the principles which Newport News was systematically developing starting in the early 1920s.

Genesis of the "Group System of Material Control"

As of the start of WWII, the acknowledged leader in scientific management applied to shipbuilding in the world was the Newport News Shipbuilding and Dry Dock Company of Newport News, Virginia. This had not been the case at the close of WWI when they were considered one of the least efficient shipyards compared to others such as Wm. Cramp in Philadelphia, Pennsylvania, the Fore River yard in Quincy, and the New York Shipbuilding Corp. in Camden, New Jersey. Faced with the possibility of shutting down at the end of WWI, the company in the early 1920s undertook to build several hundred riveted steel railroad cars for the Union Pacific Railroad. The project was under the direction of K.D. Fernstrom, later Professor of Business Management at MIT, his assistant was W.E. Blewett, Jr. who was to be President of Newport News during the war years and later president of the Society. Prior to WWII Fernstrom had set up Fairbanks Morse diesel engine assembly on a production line. He did the same for the Newport News railroad car construction project with subassemblies being built on feeder lines to the several final assembly stations. The subassemblies and other loose parts and components to be incorporated at each final assembly station were listed on station bills of material, and the parts and subassemblies so listed were fed to the final assembly stations as required to maintain the scheduled movement of the cars down the line.

The then-President of Newport News, Homer Ferguson, impressed with the efficiency of the operation and its profitability, hypothesized that the principle of disciplined control over the availability of material at work stations could be applied to building and outfitting large ships even though a moving assembly line was not practical. This insight was to prove as important to implementing scientific management in the shipbuilding industry as the invention by Henry Ford of the production line was to the manufacturing industry as a whole. This was the genesis of the Newport News "group system of material control" whereby all installation materials and equipment for specific tasks or "groups" were designated or allocated against the total quantities required on the system arrangement drawings. An ideal group was defined as that material that could be used by a tradesman and his helper in the period of one to two weeks (80–160 man-hours). The "group" (or control unit) and its scope could be preplanned at the contract plan stage

and thus be used as a "common denominator" for scheduling all design as well as procurement, manufacturing and construction activities and the identification of prerequisites to a given "group" and its dependencies.

In turn, it then became possible to set fully coordinated and definitive schedules of requirements on all of the engineering and design departments as well as procurement, manufacturing and, of course, erection and outfitting geared toward meeting contract delivery dates most efficiently, and it became possible to truly apply the "management by exception principle" to shipbuilding. Scheduled actions which had not occurred as scheduled were put on "delinquent lists" and these became agenda items for periodic production management meetings. Further, progress curves by departments could be maintained in terms of "work units" and rates of accomplishment measured against requirements, and adverse trends corrected. Labor loading by trade could be accurately forecast, planned for, and balanced between trades. Proposed changes in scope could be analyzed, for their effect on ship schedules, and accepted or rejected accordingly. Ship completions could be accurately forecast and contract commitments met.

As a refinement of the planning process, the concept of "dependent sequence" analysis and planning was developed to insure that the best construction and installation sequence was developed, and in turn that plan release schedules were geared to getting out plans in the proper sequence (the keel before the smokestack or mast) and managing the application of design manpower most effectively in support of the planned ship construction sequence and schedule. Prerequisites to and dependencies on each task in every department were identified. This interdependency planning was the model used in developing the computer-aided networks developed in the late 1950s which are now used almost universally in the heavy construction and aircraft industries and, sadly, only to some degree in shipbuilding. The most famous of the early software systems was the Program Evaluation and Review Technique [PERT] used by ADM Raborn on the POLARIS program (of which more later).

Computers and even punched card tabulators were not available in the 1920s so there was no thought of estimating, budgeting and collecting cost by group, or of building up work load forecasts by integrating man-hours for "group" work scheduled for accomplishment in each calendar interval. Costs were estimated, budgeted and collected only in terms of between 20 and 40 cost accounts depending on the shipyard.

While material and manufacturing were scheduled to support the "group" schedule of requirements, the parts subassembly and materials were not precollected, as in the case of the kits at the final assembly stations of the railroad car production lines.

Nevertheless, this "group" system, which was made operational about 1930, enabled Newport News to become so relatively efficient that by 1940 the yard's management system represented "par" for shipbuilding throughout the world.

A WWII Emergency Application of the Group System

We return to the case of the Cramp Shipbuilding Co. as a perfect example of the power of the Group System used as a management tool and applied as an emergency measure in WWII.

When Cramp's was reactivated in the fall of 1940 an unfortunate decision was made to adopt a piecework incentive system based on preplanned tasks for each operation. The "standard" times were to be estimated and adjudicated with the CIO union before starting each task. No work could be started without a work ticket issued by central planning. It was based on the system used in the Hog Island yards on the simple riveted ships of WWI. The Cramp workforce of 13,000 men had been built up in the course of a year by building fleet tugs, floating workshops and a series of major conversions of huge ships to troop carriers. This work was carried out without the "benefit" of central planning! As the cruiser work started to phase in, a group of "planners" were busily engaged in writing work tickets. No work could be done without one. Even with a force of 200 persons working on them the tickets were not being produced fast enough nor was the union agreeing to the work ticket budgets. Work was grinding to a halt. The president of the shipyard died suddenly. A less qualified interim chief executive officer tried to eliminate the clause in the union contract calling for agreement to the standards. The union went on strike. What to do? The writer recalled his MIT Professor K.D. Fernstrom describing the genesis of and benefits of Newport News' Group System. But he was in North Carolina on leave from MIT and starting up the North Carolina VICTORY yard. I drove down to see him over a weekend. They were not yet in production. He arranged for me to return to Newport News and see the president, W.E. Blewett. Blewett turned me over to V.P. Lloyd Sorenson and Production Engineer Fred Robinson. They took me through the entire planning, material control and production control cycle step by step, armed me with their famous "green book" [3] describing the system, examples of all the paperwork involved and the implementing management practices, and sent me on my way (but with an open invitation to return if I had questions).

Back in Philadelphia a new president, H.E. Rossell, had been installed. Rossell, a noted Naval Constructor, had taken leave from MIT, where he had charge of the naval constructors studying there. He settled the strike – eliminating the offending contract clause. In the meantime, construction of the first cruiser was not proceeding at a satisfactory rate. The trickle of work tickets restricted the work. And without installation tasks defined in terms of material required, and the manufacturing and assembly bills of material indexed to them, the right material was not getting to the ways at the right time. Rossell put me in charge of cleaning up the mess and doing what was necessary to get the Group System installed. This would require an intense effort of several months. To buy time with the trades, I issued an edict – "Until further notice no work tickets would be required. Anyone with a plan, who could scrounge up the material was free to go ahead and do what he could." (Much was accomplished!)

We then set to work to create a comprehensive group index, or, in today's terminology, "a work breakdown," structure, and to schedule it. Turning to the trade-leading men and quartermen, I pulled them together evenings to "scope" the groups or work tasks to suit their own trade practices. This was done under the direction of Harlan Turner, an MIT classmate who had worked at Newport News. In the meantime several of us pitched in and created a comprehensive chart of accounts–an industry first–within which approximately 5000 erection and installation groups and supporting manufacturing B/Ms could be indexed and accounted for–within ship systems. As the tasks were scoped and systematically identified, we had a small army of conscripts from every walk of life, working on two shifts to appropriately allocate all of the material on the plan to one or another group. An invaluable byproduct of this effort was to identify and correct discrepancies in material requirements

between the body of the plan and the plan bill of material The groups and supporting manufacturing B/Ms could then be identified to their prerequisite groups and plans or work units, and we had the basis of an integrated management system which could now include not only the yard trades but engineering, design, procurement, stores and inventory management Requirements for stock materials could now be forecast with precision based on specific requirements against the time scale. The first six months of partial application in the yard reduced delinquencies in the machine and turret shops from 90 percent to less than 10 percent Installation costs were cut by more than 50 percent The light cruiser ASTORIA delivered in June 1944 was cited by the Navy as the most complete ship of its class ever delivered to that date Particularly notable was the fact that her fire control system was completely groomed, integrated and operational. After her river trials and delivery, instead of spending 6 to 9 months or more at a naval yard to groom her weapons systems, as had been customary on such ships from the great Newport News, NewYork Ship, and Quincy yards, ASTORIA picked up ammunition and stores and her full complement of men and went directly to sea and into combat This practice was to become the industry standard.

We also achieved another major milestone on the scientific management front By virtue of our own comprehensive cost account structure, we had proven that it was possible to do the "impossible" by collecting man-hours by 5,000 or more specific tasks as opposed to the traditional 20 to 40 accounts, and creating a data bank of that information on punched cards We were on the way to integrating cost estimating, cost control and even labor load planning with the basic planning, engineering, manufacturing, and material control systems! The basis had been laid for more spectacular advances of the state of the art of a shipbuilding management that would be demonstrated on the nuclear submarine program at EB in the 1950s

Of equal significance were the final man-hours required to build the Cramp cruisers The hours for fifth cruiser, WILKES BARRE, were less than Bethlehem ships built at Quincy, equal to returned hours at the lead yard, New York Ship, and exceeded only those of Newport News which had so kindly provided us with their "know how" The results must also have been of quite some considerable satisfaction to the yard's owners, W Averill and E. Roland Harriman. (Our chairman was "Joe" Ripley, also chairman of Harriman-Ripley) The ship costs were under the target costs set in the contract and thus earned substantial bonuses in accordance with the contract. The Harrimans had a tenfold return on their net investment of $1 million in the reopening and rehabilitating of the yard.

Management Systems – State of the Art – Close of WWII

At the close of WWII, the Newport News Group System came the closest of all systems in use in the major shipyards to qualifying as a fully integrated system capable of designing and building a variety of complex combatant naval vessels in parallel and to tight schedules. The Newport News Group System was replicated with impressive beneficial effects during the war to help Cramp Shipbuilding Corporation in Philadelphia recover from a bad start in the construction of cruisers and submarines. At Cramp we were also able to ratchet the system up a notch or two by refining the cost system and by integrating it with the material control system The essential elements of this advance were

- a comprehensive book (chart) of accounts embracing every system
- the recording of costs by units of work (groups or work packages).
- keeping track of the 5,000 or so unit cost records per ship on tabulating cards using IBM tabulating equipment
- analyzing variance in costs over budget on an ongoing basis and taking appropriate remedial actions

New York Ship had an excellent material control system which supported orderly, expedited design and construction of a variety of major ships.

The Quincy Bethlehem Yard had a demonstrated capability of planning, designing, and building several classes of combatant naval vessels – some in astounding quantity This is illustrated by the Bethlehem-Hingham yard Started from scratch under the direction of Samuel Wakeman, it alone built a total of 227 British and U.S. Navy vessels during the war.

Bath and Electric Boat were building great quantities of like ships in series, taking advantage of "learning " Ingalls, building in series also, enhanced their production with "standards" for all tasks in conjunction with an incentive system But the best-managed of the assembly yards engaged in building complex naval ships in series was, in my opinion, the U.S Steel-owned Federal Shipbuilding and Dry Dock Company in Kearney, New Jersey For forty years thereafter, I carried in my wallet a 1941 quote from a paper by L. H Korndorf, Federal's president It says it all.

> "Coordination is of the essence. No single element in shipbuilding is sufficient unto itself Workers without plans and materials would produce nothing, just as plans and materials without workers would not build ships."

Unfortunately for me, I never met Mr. Korndorf, but I was well acquainted with the general manager of that yard. Gordon Holbrook, who freely shared his vast know-how both with his peers, and others less experienced, such as myself

Performance in the WWII Liberty Shipyards

The very large range of performance between shipyards for identical ships in a series can best be illustrated with actual man-hour data from the 15 yards dedicated to the construction of Liberty ships in Word War II as recorded by Lane [4]. This data is graphically illustrated in Figure 2, which summarizes the data for the best and worst performing yards and the average for all 15 yards.

As will be noted in Figure 2, the Bethlehem-Fairfield Yard was a close second to North Carolina's performance. Both yards had the benefit of a few experienced managers, planners, and logistic support from the parent companies.

Table 2 shows the "improvement" as calculated using post-WWII learning curve theory derived from analyses of the actual direct labor man-hours in aircraft plants and, to some extent, in shipyards, during WWII. Since all 15 Liberty yards were started up from scratch using untrained workers, and the facilities could be considered equal, the enormous difference in man-hours per ship that continued through the eighth round and beyond can only reflect the preplanning, material, and cost control disciplines which were applied effectively at North Carolina, as opposed to the relative lack thereof at most of the other yards.

Figure 2. Man-hours per ship for Liberty ships, by rounds (average for each successive round of the ways in selected

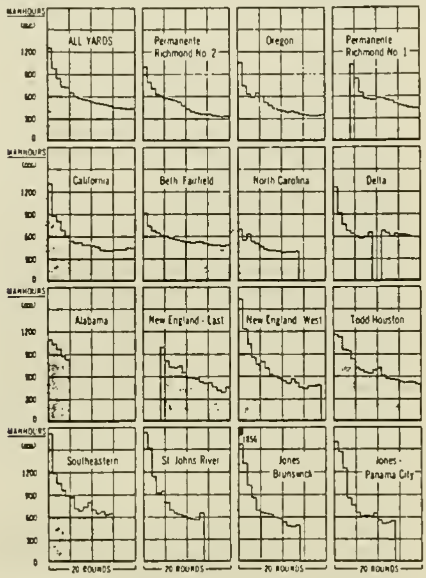


Table 1. Performance improvement by rounds – best and worst performing yards

Round (6 ships)	Man-hours per ship, in thousands: 15 yards average	North Carolina	Jones Brunswick
First	1,120	625	1,856
Second	975	550	1,350
Fourth	725	525	875
Eighth	590	410	630
Sixteenth	450	400	525
Improvement	*81–82%*	*87.5%*	*70%*

Had the North Carolina ships been built at Newport News, where full advantage could have been taken of that yard's superbly trained work force, it is probable that the North Carolina ships would have experienced a better learning curve – 94 percent – as opposed to the 87.5 percent which they did experience. Based thereon and backing from the 16th round of ships to the first, the per-ship cost of the first round of ships would have been 490,000 hours, had they been built at Newport News. The difference between this and North Carolina's actual initial rounds-per-ship cost is 135,000, and represents the savings on that ship that can be attributed to start-up costs in the new facility, including the on-the-job training of a new management infrastructure and work force, directed and managed, nonetheless, by a tiny cadre of skilled shipbuilders in terms of a coherent planning and control system. As it was, the North Carolina actual hours were but a third of what were expended on Jones-Brunswick's first round, and half of the average for all yards. The three Kaiser yards, which in the end performed admirably, would, no doubt, have performed better on the first few rounds had they not slavishly used my 1938 MIT thesis as a basis for their yard layout. (See WWII Shipyard Layouts, page 4). As it was, the average of their costs for the three yards by the end of the fifteenth round had leveled off at slightly less than 400,000 man-hours per ship, and a shade lower than North Carolina. From this distance, I must conclude that the Kaiser yards were extremely well managed!

Had all 16 yards performed as well as North Carolina over the course of 16 rounds, one can determine that about 280 million man-hours (or 31 percent of the 911 million man-hours actually expended) would have been saved. This, if necessary, could have been used to build even more ships (or in these days reduce the national debt!)

The variations between the performance of the 16 yards in total man-hours per ship for the initial rounds is a splendid illustration of the importance of managing single ships and small groups of sister ships with the highest degree of professional ardor and to the upper limits of the state of the art (such as, in this case, the Group System), if financial success is to honestly accrue based on performance.

Learning Curve Theory

After WWII, using the data from aircraft manufacturing and, to some extent, shipbuilding, a Learning Curve Theory was developed, including a mathematical formula for arriving at the improvement percentage. During the 1960s, 1970s, and 1980s, it was widely used in estimating costs of a series of ships and arriving at bid prices, and in negotiating contract costs. Used with educated discretion, the theory is useful. The unscrupulous, however, have used it to justify after-fact cost overruns attributable to their failure to manage contracts in acceptable, state-of-the-art manner [5].

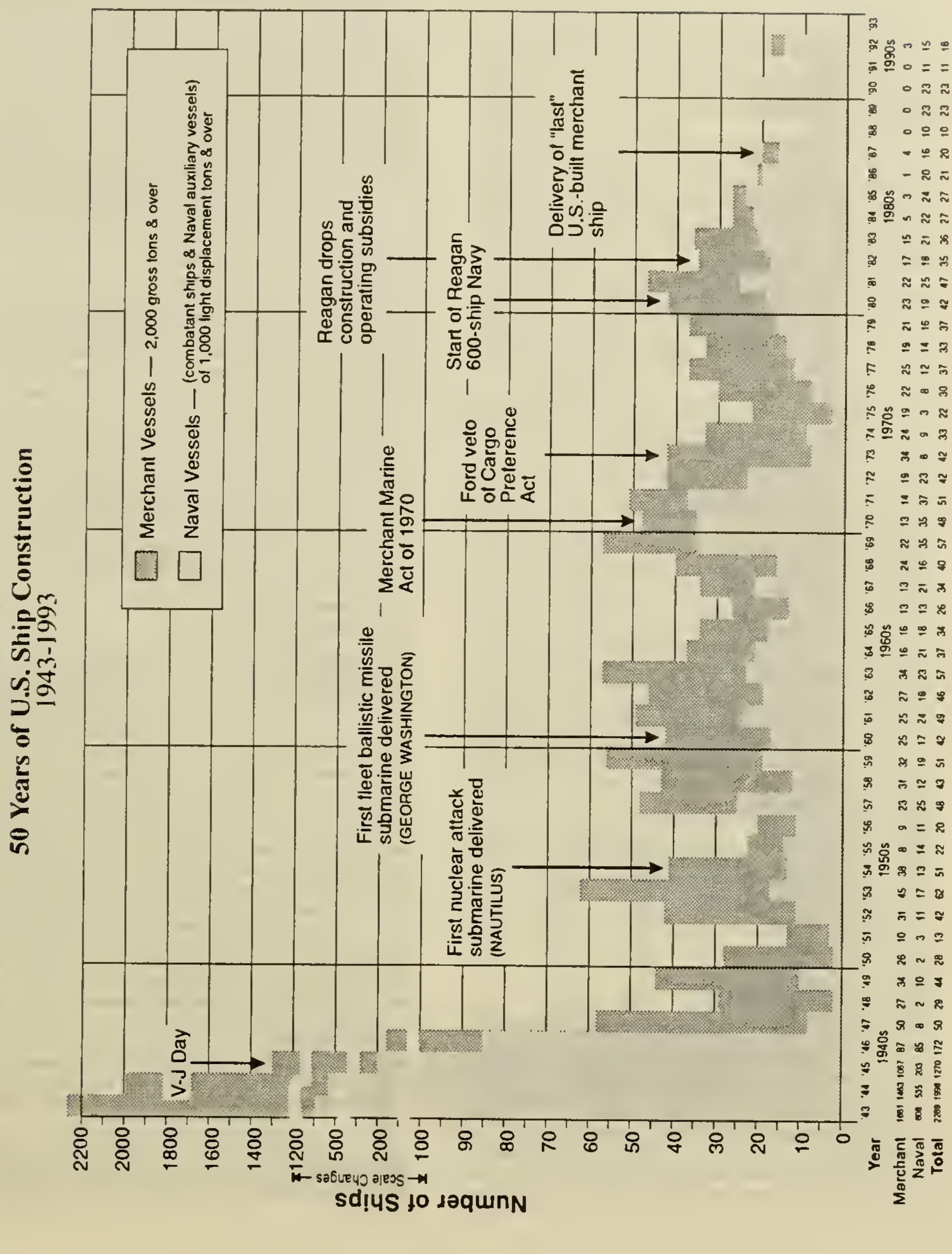
U.S. SHIPBUILDING, 1945–1991

Overview

After VJ day, the gigantic shipbuilding industry of WWII rapidly sank back to its prewar size. In 1947 only 53 ships were delivered – 8 naval and 50 merchant. 1948 saw only 28 ships delivered – 2 naval and 26 merchant. In the 43 subsequent years, total deliveries of naval ships and commercial ships (of 1000 gross tons or over) have proceeded in waves between these two limits, but with the production of merchant ships greater than 1000 gross tons reducing to zero by 1988. In each of the years 1989 and 1990, 23 naval vessels of over 1000 displacement tons were delivered. This picture is shown graphically in Figure 3.

The gyrations in commercial shipbuilding and its complete cessation in 1988 construction reflected a continued lack of consistent U.S. maritime policy plus the maritime unions' success in pricing U.S.-flag ship operating costs out of the international market. Ship construction subsidies were dropped in 1981. It remains to be seen if U.S. construction of merchant ships of greater size than 1,000 gross tons will ever be revived. A possibility exists as a function of the August 1990 congressional

Figure 3. Fifty Years of U.S. Ship Construction, 1943–1993.



Source: Shipbuilders' Council of America

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mandating of double hull tankers for carriage of oil to U.S. ports.

Nevertheless, many splendid and innovative ships were built in the period between 1946 and 1988, a number of them stimulated by the Merchant Marine Act of 1970. These included ever-larger oil tankers, container ships, Ro-Ros, cargo liners, barge-carrying ships (LASH and Lykes SEA BEES), and Sun Ship's prophetic double-hulled "ecological" tankers of 125,000 DWT.

In 1948, Bethlehem produced in their Central Technical Department at Quincy a proprietary 28,000 DWT oil tanker design of which 24 or so were built and marketed worldwide. They were followed during the 1950s and early 1960s by a series of 24 48,000 DWT tankers. This impressive series production program was carried out in the Quincy, Sparrows Point, and San Francisco yards. They were built without subsidy.

In 1950 VAdm. E. L. Cochrane took a two-year leave from MIT, where he was heading the Department of Naval Architecture, to take charge and reorganize the Maritime Administration. During that time, the MARINER program was conceived and launched. Forty-three of this class were built over the next few years.

Several classes of general cargo ships were also built in smaller quantities at Ingalls Shipbuilding Corporation in the 1960s and early 1970s for Delta Lines, American Presidents Lines, Farrel Lines, and Moore McCormack Lines.

A more consistent naval shipbuilding program has over the years been driven by the perceived threat of Soviet naval force, the land-based missile threat of the Kruschev era and continuing intelligence appraisal of the strength and efficiency of Soviet ships and their weapons systems – all excellent for producing congressional budget approvals. Many splendid submarines and surface ships were built which advanced the state of the art and complexity of ship/weapons systems by orders of magnitude and the size and cost by several times. But this otherwise outstanding naval shipbuilding effort, and in some important sectors the commercial shipbuilding efforts, was tarnished by poor schedule and budget performance by some major shipyards to which ill-conceived, politically imposed changes in the naval design and procurement organization and practices contributed in the 1960s. This led to massive constructive claims, many of which bordered on or were fraudulent. These claims reached their peak in the 1970s and early 1980s. The hoped-for solution has been to explosively expand general provisions of the Federal procurement regulations!

As regards shipyards – whereas we came out of WWII with 19 large yards capable of building quantities of ships of over 1000 gross tons – there are now only 7. These are:

Newport News
Electric Boat (submarines only)
Bath Iron Works
Avondale
Sparrows Point
NASSCO
Litton/Ingalls West Bank (supported by East Bank facilities)

Computer-aided systems of planning, material control and other logistic supports to the shipbuilding process have been increasingly adopted with great effectiveness, particularly in the submarine building programs. In recent years, a literally furious effort has been mounted by both NAVSEA and the shipyards building naval ships to realize the potential benefits of CAD/CAM to enhance the design process and do away with conventional arrangement and detail drawings, mock-ups and even pencils. This would have many ancillary advantages relative to preparation of B/Ms and specifications and importantly the ready transfer of technical information between NAVSEA, other design agencies, shipyards, overhaul and repair yards and ships at sea. The prospects of success are real – but as yet largely unrealized. Impressive strides have been made by the Navy in advance planning of overhauls and shipboard maintenance by the Navy starting with PERA in 1969, the real success of which can be measured by the lengthening of time between overhauls. The effort has reached back into the conceptual and preliminary ship design stages of shipbuilding – the ability to pass over 90 percent of all ship components through "logistic hatches" on the latest submarines being but one example. The Navy's phased maintenance program, which now applies to ships of all types, has allowed for preplanning, shortened overhaul schedules and impressive attendant economies in overhaul and conversion work.

Sadly in the case of naval new construction, the technical ability of NAVSEA to prepare concept, preliminary and contract drawings specifications and thus control the scope of that for which they contract, was nearly wrecked by the MacNamara dissolution of BuShips in the late 1950s. It has never fully recovered and even now is in danger of extinction due to the proliferation of politically oriented oversight functions in the Navy and Pentagon, all sensitive to White House and congressional pressures. The Maritime Administration's former technical capabilities have all but disappeared!

The changes in the overall naval ship design and ship acquisition process have been well summarized in a 1991 study, "Improving the ship design acquisition and construction process," sponsored by the Navy's Chief Engineer RAdm Roger B. Horne, Jr. [6] The study also decisively identifies a broad spectrum of necessary improvements.

The following paragraphs are taken from the study's summary of the current state of affairs:

> "Thirty years ago the fact that the Navy designed its own ships with in-house resources was a given (in-house would also include farmed-in naval shipyard personnel). Compared to today, the number of design deliverables was small, and the time required to accomplish a design was short. Ships were less fully integrated–partly because they were less complex, and partly because different Navy organizations (Bureaus) were responsible for the platform and the weapons. In the 1960s ship design and acquisition underwent major changes. Under Total Package Procurement several classes of major warships were assigned to industry for design. In the 1970s a system analysis/engineering approach began to be applied to ships, with a consequent exponential increase in design (paper) deliverables, and a significant increase in design time as well. Due to staffing shortfalls, increased use was made of civilian shipbuilders and ship design agents even for Navy in-house designs. The "platform" and the "weapons" Bureaus were combined. Program managers/platform directors came into being which added a layer between those who set requirements and those who designed ships. For some years, the office of Chief of Naval Material (CNM) added a layer between the Systems Commands and OPNAV. CNM was abolished in the 1980s, and SPAWAR (Space and Naval Warfare Systems Command) was established and assigned some of CNM's responsibility.
>
> "The shipbuilding industry had undergone several fundamental changes. Thirty years ago, many first-of-class warships were constructed in Navy shipyards, and ship

construction was frequently assigned to private yards on an allocation basis Ship specifications were primarily engineering documents, rather than legal ones The Navy and its principal shipbuilders did not exhibit an adversarial relationship Claims were rare, and there was a substantial (by today's standards) market for commercial ships During the late 1960s Total Package Procurement and multi-year awards enjoyed what turned out to be a brief vogue During the 1970s most of the shipbuilders began to lose money on Navy contracts The reasons were numerous (some beyond the control of either the Navy or the shipbuilders) Massive claims resulted, and an adversarial relationship evolved. In the 1980s several major events occurred:

- U.S. shipyards began to adopt modern shipbuilding practices.
- Ironically, at the same time, the commercial shipbuilding market started to shrink, and eventually all but disappeared.
- Acquisition cost became the overriding consideration in awarding contract (coincidentally lead ship awards were often fixed price – a departure from previous practice).
- Many of the small-medium size shipyards went out of business A small number of large shipbuilders won the vast majority of the Navy contracts There is now one buyer of ships in the U.S (the Navy) and about a half dozen sellers (the major shipbuilders).

"The U S Navy, along with the other services, is adjusting to major changes on both the national and the international level The perceived reduction in the threat of a major war with the Soviet Union has major ramifications for the Defense budget How many ships (force level) and of which type (force mix) the future Navy will require, and can afford, is unclear Emphasis could conceivably shift away from big-ticket high-mix surface ships (CVNs and Aegis escorts), towards amphibious assault ships, fast sealift and smaller combatants (frigates and destroyers).

"As the choices become more difficult, due to a shrinking SCN budget, early stage design activity may in fact increase as OPNAV asks more and more "What if?" questions in an attempt to reconcile what they need and what they can afford Today, the five shipyards which build CVNs, nuclear submarines, Aegis ships and major amphibious ships consume the majority of the Navy's SCN budget. If future SCN budgets provide for fewer of the above, and more sealift, smaller amphibious ships and smaller combatants, the number of shipyards qualified to bid will increase "

The growth in spantime from the start of the ship acquisition time to delivery for surface combatants is shown in Figure 4. The equally dramatic (or perhaps more so) growth in contract design effort is show in Figure 5, and the growth in combat systems cost "fractions" is shown in Figure 6. Trends with respect to submarines are discussed under "Submarine Design and Construction," pages 19–22.

Contracts & Contract Management

Prior to WWII, ship contracts, both Navy and commercial, were generally of a simple fixed price nature Generally contract plans and specifications were developed, but in some cases

*Figure 4. Combatant ship aquisition time feasibility to delivery**

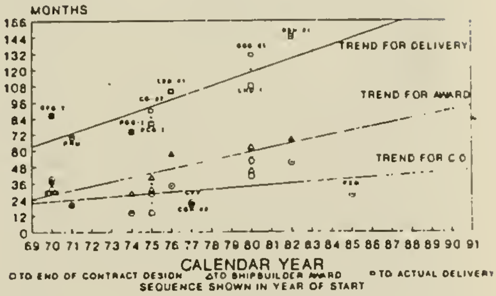


*Figure 5. Contract design effort for major surface combatants **

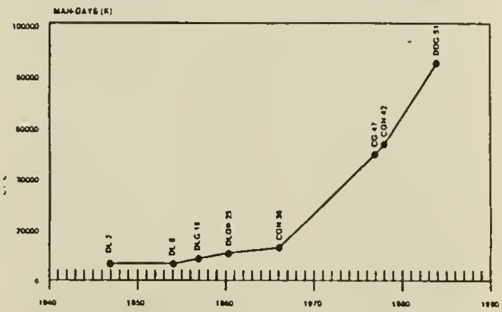
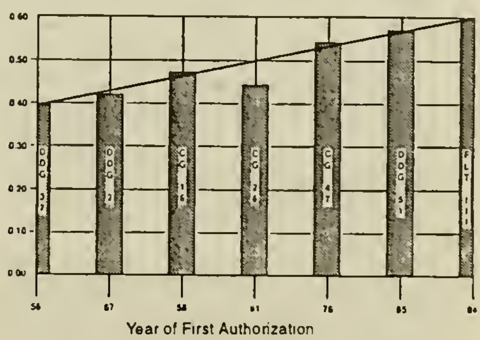


*Figure 6. Growth in combat system cost fractians **



*Source "Strategic Plan for Improving the Ship Design, Acquisition and Construction Process." Vol I, June 1991 [6]

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where integrity and mutual respect existed on both sides, the contract consisted only of a statement of performance requirements, a handshake of understanding and a confirming letter contract. The best practice with respect to contract changes identified by either party was to "scope" each perceived change, estimate the cost and negotiate a price therefor before commencing work thereon.

The emergency demands of WWII required the extensive use of letter contracts for both shipyard facilities and construction of the ships. These letter contracts got the work started and were later converted into any one of a variety of formal contracts. After WWII the general Navy practice was to contract for prototypes on a cost plus a fixed fee basis, and for follow-on ships on a firm fixed-price basis. For example, when prototype nuclear powered submarines and their prerequisite land-based power plant prototypes came on the scene in 1950, the initial contracts at Electric Boat were on a "handshake" with commitments for long lead items often being made without any paper whatsoever having been signed. A letter contract would be signed some weeks or months later. At approximately 20 percent into the span time of the contract either a CPFF or more generally a CPFF incentive-type contract would be negotiated. Such an approach greatly facilitated building the prototypes in the least time, and it was used right through the contracting (by handshake) of the first POLARIS missile submarine, the USS GEORGE WASHINGTON, on December 30, 1957. In the case of the Electric Boat, the process was vastly enhanced by the comprehensive and integrated planning, material, production and cost control which was in force over all phases of the yard work and its prerequisite engineering design procurement and manufacture commencing early in the 1950s. (Engineering and management and customer decisions were also scheduled and rigorously "forced" on or ahead of schedule.) Thus EB had the ability to consistently design and construct several different prototype contracts to abbreviated contract construction schedules simultaneously – to say nothing of balancing the work force and evaluating the effect of both potential business and contract changes and making prudent decisions with respect thereto. Nevertheless the finalized contracts for nuclear submarines and their power plant prototypes perforce included new and increasingly rigorous provisions for radiation protection, monitoring of exposed workers, compliance with nuclear performance and inspection specifications, use of entirely new and exotic metals and alloys, qualification of welders, stringent requirements for welding and heat-treating processes, security protection for nuclear reactors and indemnification provisions for the shipbuilder under public law 85-804. Change orders were handled in the pre-WWII fashion. The same basic approach to contracting was pursued by the Navy in other shipyards doing high-priority work. At EB there were no contract "disputes" requiring resolution at higher levels than the local contracting officer (or ADM Rickover in the case of the nuclear plants) and the shipyard manager. Constructive changes (or claims) had not yet been invented.

One of the first constructive claims in the shipbuilding industry came when a former Navy General Counsel coached the TODD Shipbuilding Corporation in the preparation and filing of same in connection with overruns of approximately $100 million on a number of Navy vessels in 1967. This claim was "settled" favorably to TODD by the then Chief of BuShips, RAdm Nathan Sonenshine. The concept spread throughout the Navy shipbuilding industry like wildfire – the flames being fanned by not one but two former General Counsels of the Navy, VomBauer, Cumeo and their respective associates. These former General Counsels well knew where the "loopholes" were in the Armed Services Procurement regulations. They were enthusiastically joined in coaching various shipyards by a number of prestigious accounting firms.

The essence of the sales pitch of these legal pirates was that no change should be signed, priced or negotiated during the course of the contract. When the work had been completed and the ship or ships delivered, and depending on the size of the total cost overrun (often several times more than $100 million), one or two hundred naval architects and engineers were to be assembled. Each was to be assigned one or more cost accounts and a budgeted portion of the overrun and ordered to develop plausible reasons for the overrun in their assigned portion complete with engineering sketches, diagrams, graphs, statistics and written rationale in large quantities–the more the better.

The lawyers and accountants would then prosecute the claims, which embraced all costs in excess of contract plus the generally multimillion dollar cost of preparing the claim plus all professional fees plus interest and profit on the entire increment. The prospect of collecting these vast sums naturally appealed to the increasingly "bottom line" oriented conglomerate managements who now owned most of the large shipyards and took financial advantage of their large cash flows. The new claims industry was thus established. The insidious beauty of the constructive claim was the bigger the contract overrun the better, and thus there was a specific disincentive against pricing or managing ship contracts for efficiency and the lowest man-hours. The industry total for asserted but unsettled claims was to grow to $300 million in 1971 and then explode to $2.7 billion by 1977.

In most cases little if any weight was given to the merits of the many elements of the claim by those preparing them, the burden of the proof that parts of the claims were largely without merit falling on the understaffed, underbudgeted technical staffs within BuShips and the office of the Navy General Counsel, to whom the claims were submitted. The chances that fraudulently prepared elements of the claim would be authoritatively identified by the Navy were minimal. When they were, the contractor could and did still win the case in either the Armed Services Board of Contract Appeals or the Federal Courts (in the case of clear-cut fraud cases) by the simple and profitable expedient of applying overwhelming (and government financed!) legal fire power plus arranging decade-long delays in bringing the cases to trial, all to the contractor's financial advantage and at the government's expense! While a significant portion of the claims would be related to direct costs, increasingly over the years larger segments would be attributed to delay and disruption and to "second and third order ripple effects" justified successfully in at least one case through the employment of computer simulation modeling [7].

The final resort of course was extreme political pressure to bring about a settlement under public law 85-804 in order to prevent "disruption" of the defense posture of the U.S. Other factors in the size of the claims were that Navy estimates and budgets for ship costs were "shaded" on the low side, in order to make them acceptable to the Pentagon and Congress, and the inadequacy of price escalation clauses. Also contractors' bid prices were often deliberately set below the yard's best historical performance to come within the Navy's budget and/or to wipe out the competition, the expectation being that the yard could make up the difference in the course of negotiating change orders and, starting in 1967, by constructive claims.

By 1969 both the Litton Ingalls yard and the Quincy yard of General Dynamics had incurred cost overruns of several

hundred millions apiece and were deliberately stalling on settling individual changes on advise of claims counsel Internal audits (in both cases directed by myself as General Manager) showed that both yards had consistently priced ships below their best past performance by 30 percent or more.

The writer began to uncover this situation at Ingalls in late 1968 when I found that several shops were performing at an all-time peak of efficiency based on Ingalls's well established standards but were not meeting the management budgets derived from the contract cost estimates. My call for a write-off on a current contract was not appreciated by Litton's Beverly Hills-based financial wizards, especially because the Litton price-earnings ratio had faded almost overnight in the fall of 1968 from 100 : 1 to 50 : 1 Litton (which by that time had acquired 100 different businesses, of which the Pascagoula shipyard was the largest) had, it seems, publicly promised the financial community that it would produce the largest profits in its brief history in the fiscal year ending July 31, 1969 This was made good on by postponing the write-off until the next fiscal year while I found myself reopening an earlier offer from General Dynamics to return there as a corporate vice president and general manager of their crisis-ridden Quincy shipyard At that yard GD had already written off $200 million of what was to be a nearly $400 million loss on underpriced naval ships backlogged in the yard Some of these ships were years behind contract delivery dates

On my first day as general manager at Quincy, and out of curiosity, I opened the door of my conference room. It was full to the brim with my entire shipyard staff, whom I had not met, and two other strangers – Atty David Anthony, a Cuneo partner, and a managing partner of Arthur Andersen They were in the process of explaining in detail how to organize a claim covering the total Quincy overrun on the basis described above and collect the lot I dismissed the meeting and told these strangers that I could not turn the shipyard around if every member of "management" who had contributed to the Quincy overrun thought that his sins of omission and slack management would be recompensed with interest and profit. I would personally review each element of any claim and submit only those that I found to be a clear responsibility of the Navy. They would be barred from the yard unless they agreed to help toward that end. The next day – the second of my GD reemployment – I was summoned before the GD chairman, Roger Lewis, in New York. The GD Financial VP of that era said "This guy Bergeson is screwing up the works." I said, "Mr. Lewis, I can turn your yard around only if the claims are handled on my terms. Otherwise we should part company today." I won that battle but not the war. The Quincy claim when submitted in 1972 was for approximately $90 million and it was accepted without demur. The balance of the overrun – nearly $300 million – was not submitted as a claim, it being adjudged by me and my staff that it was due to Quincy mismanagement and therefore GD's responsibility In the meantime, I had delivered the backlog of naval ships and the Lykes Seabees as well as conceiving, designing for production, engineering and marketing the Quincy 125,000 cubic meter LNG ships with their spherical tanks of 5083 aluminum (the first large ship structures designed by finite element analysis). However, my leaving of some $300 million of claim money on the table apparently rankled sorely in the souls of GD Chairman David Lewis (Roger Lewis' replacement) and controlling stockholder Col. Henry Crown. They had what was to be "the last laugh."

After a contract for eight LNG ships had been signed with Burmah Oil Co. in late 1972, General Dynamics started off 1973 by replacing the writer as general manager with P Takis Veliotis, a Greek national who had already been the subject of a well publicized "Crown" (in this case – government) investigation in Canada for fraud and kickbacks on government shipbuilding contracts in Canada At Quincy, Veliotis pursued his practice of requiring kickbacks from vendors and subcontractors in spades despite Chairman Lewis's knowledge (later admitted) that it was going on! Since 1981 a fugitive from U.S. Justice in Greece for his court-documented peculations at Quincy, Veliotis was awarded the Society's "Emory S. Land Medal" for his shipbuilding "achievements" in 1980.

According to John Noga, recently retired Director of Contracts at Electric Boat, the groundwork for massive claims from both Electric Boat and Newport News was laid in July 1974 when ADM Rickover pushed through fixed-price incentive programs for the OHIO (TRIDENT missile) class of FBMs, which was to be designed and built at EB, and the 688 class of attack submarine,s which was to be designed at Newport News and built at both yards. There were also fully priced options for follow boats. Both classes of ships were to be built on relatively tight schedules and managed on a "crash" basis emulating the successful POLARIS program of nearly two decades earlier

That approach might have worked at Electric Boat, at least, if that yard had kept its management, planning and control functions at the peak of effectiveness reached in the mid-1950s, maintained through the early 1960s, and demonstrated so effectively on the POLARIS program. But by the mid-1970s that effectiveness had all but disappeared. The "fly wheel" inertia of the basic material control system was keeping useful work under way but not coordinated in support of schedule. The reasons for the loss of this ability was twofold. First, a series of successively less qualified and dedicated general managers, and second, years of building virtually the same ships in series that had allowed planning skills to atrophy! Thus they could not cope incisively within the allowed time frame with 688 plans designed to suit Newport News manufacturing practices but which had to be altered before they could be used for production in Quonset Point or Groton. Electric Boat was also in deep trouble on the TRIDENT program. By 1977 a six-month slip in schedule of the latter program had been announced by the Navy. This was but the precursor of actual delays beyond contract deliveries of 23 to 28 months.

Rickover had been in effect "hoisted by his own petard." He and his people had apparently believed that EB's outstanding engineering and production performance of the 1950s and early 1960s had been induced by his ruthless pressure tactics applied in large part via his several hand-picked nuclear project managers within EB In fact the disciplined and balanced effort required to simultaneously engineer and build the prototypes and maintain them to their respective schedules had been applied by the EB line organization despite his disruptive pressures.

Along with the delays in the TRIDENT program and similar ones in the 688 program came claims from Electric Boat and Newport News in total face value amount of $814 million. The claims were filed against 23 SSN 688s (18 at Electric Boat and 5 at Newport News) at a time when only one ship had been delivered.

Bad enough that the TRIDENT and 688 programs were imposed on the EB organization when the yard was effectively out of control in terms of the standards in force circa 1960. The situation was worsened, first when Gordon MacDonald, a David Lewis corporate henchman, was made acting general manager in the mid-1970s and then late in 1977 when he was

replaced by P Taki Veliotis. This latter action, apparently insisted on by ADM Rickover and made possible – security-clearance wise – by him, was taken despite Lewis's knowledge of Veliotis massive peculations at Quincy! Veliotis promptly worsened the already weakened management ability of the yard by firing 4,000 employees, including managers and group leaders in the design force and several key contributors in EB's planning and material control system.

The first public warning of massive overruns in the two submarine programs was made by Gordon W. Rule, recently retired as Director of Procurement Control of the Naval Material Command in a talk at Baltimore on November 17, 1977. A congressional committee subsequently concluded that the overrun and delays on the 688 program were a classic example of what can happen when the Navy "accelerates" a ship's program without the benefit of sound design data.

The congressional committee did not say that it need not happen, as exemplified by the case of the first POLARIS missile submarine USS GEORGE WASHINGTON. As discussed in more detail elsewhere, that ship and its revolutionary component systems (missile, launching and handling system, fire control system and inertial navigation system) were developed, engineered, designed, manufactured, completely integrated as an operational ship, and delivered in a total time span of 24 months from concept. The ship was ready to fire missiles in under 30 months from concept. The ship and its integrated systems was several orders of magnitude more complex than anything ever before attempted, much less accomplished, in naval ship construction! Thus it was and is within the fully proved state of the shipbuilding management "art" to build developmental ships (with their inevitable growth in scope) to tight schedules if the will is there; the managements, both shipyard and Navy are "tuned" and resolved to do it; an adequate management system is in place; and most of all if the requisite "midnight oil" is burned.

The congressional committee report concluded:

> "Therefore, the Navy should give serious consideration to awarding the lead ship of a class under a research and development contract, probably on a cost plus basis. Follow ships should not be placed on contract until at least two years after the lead ship has been fully funded."

This was just what the Naval Material Command had proposed before award, but they had received no support against ADM Rickover.

The Navy Board headed by RAdm Manganaro, disallowed in the order of 85 percent of both the Electric Boat and Newport News claims. ADM Rickover, of course, also roundly denounced them. The Pentagon made settlements on them under public law 85-804 on the grounds that the shipyard's continuation in business was essential to national security. The U.S. taxpayers were stuck with millions of dollars for contractor-responsible overruns.

To quote John Noga:

> The number and magnitude of the submarine and surface ship claims prompted the government to revise and reinforce its procurement regulations to require contractors to provide documentation of their legal basis for entitlement, provide factorial support for the amounts they claimed and to demonstrate causal support and documentation of the amounts claimed in as much specificity as the facts permit and provide a certificate of cost and pricing data signed by an officer of the company.
>
> The truth in Negotiation Act and Certification of data, as well as continued education of contractor personnel to not undertake additional work without a written change order has reduced the constructive change claims. In my view, we will see similar claims in the future. Fraud and corruption by government contractors also produced a host of additional Federal Acquisition Regulations to counter contractor abuses and to provide for costly penalties such as, debarment or suspension from doing business with the government.
>
> As a result of these abuses, additional provisions were developed and included in the Federal Acquisition Regulations such as Anti Kickback Procedures, Requirement for Certificate of Procurement Integrity, Price and Fee Adjustment for Illegal or Improper Activity, Certification and Disclosure Regarding Payments to Influence Federal Transactions, Integrity of Unit Prices, Price Reduction for Defective Cost or Pricing Data.
>
> All the corporations that were suspended or fined had to officially issue a company policy booklet stating clearly the companies' ethics policy. Each employee had to read and sign that he read the policy. Once this was completed, the government lifted the suspension. I personally do not think this ethic statement will solve company problems. One either has it (integrity) in the beginning or he does not.
>
> Over the past fifty years the events above and the effects thereof have increased the General Provisions of Government Contracts from 20 odd pages to the present General Provisions which include the provisions and clauses of the Federal Acquisition Regulations, seven volumes. It also has increased cost of doing business with the government. I hesitate to think what the 21st century will bring to government contracting.

Shipyard Layouts and Facilities, 1943–1993

Litton/Ingalls "Shipyard of the Future"

Only one major U.S. shipyard was built from scratch in the entire 50-year period 1943 to 1993. This was the land level progression-type yard which was built by the Ingalls Shipbuilding Division of Litton in 1968/69. Located on the west bank of the Pascagoula River, and opposite the existing East Bank yard, it covers 500 acres. The finished vessels are translated onto a grounded "lift" dock equipped with ballast tanks in the manner of a conventional floating drydock. Financed by the state of Mississippi, it was built on "speculation" to give credibility to Litton's strong and successful effort to capture major contracts under the Navy's MacNamara-inspired and ill-conceived "Total Package Procurement" concept. The ships hulls were to be built in very large modules which were to be extensively preoutfitted in the open prior to joining same.

Over the years in combination with the preexisting facilities of the East Bank yard, the yard has proved viable for series construction of LHAs, DDs and Aegis cruisers. But this viability was achieved only after massive delays and cost overruns of truly scandalous proportions – as documented by contemporary press reports and Litton's own financial statements. The problems stemmed basically from two predictably bad decisions by Litton's Beverly Hills management

Banning of Shipbuilders from West Bank Yard

The first illogical, and almost completely disastrous decision by Litton stemmed from the delusion on the part of Litton's President, Roy Ash, that even the most advanced shipbuilding techniques and the most skilled shipbuilders were obsolescent as compared to aerospace techniques and managers. Experienced or even inexperienced naval architects and shipbuilders were literally banned from the facilities planning and operation of the new yard at all levels. Not only did this mean that the 500-acre yard was to be seriously deficient in support facilities and equipment for the manufacture and outfitting of the ships; it also meant that basic shipbuilding procedures were ignored. Mono-detail plans were attempted. The plans for systems within modules were not integrated with one another The most rudimentary ship alignment benchmarks (buttocks and waterlines) were ignored in construction and erection of the modules. The modules did not mate and the hull of the first ship in line (for Farrell Lines) had to be scrapped It was not until all progress had ground to a halt in 1972 that the Ash decision was reversed and the West Bank management was turned over to the cadre of East Bank professional shipbuilders (which I had assembled in 1967/68 to handle the submarine construction and overhaul program on the East Bank) that the situation was brought under a modicum of control by applying the basic planning and control methods which had proved so increasingly effective over the years at Newport News, Cramps, Electric Boat and elsewhere and which by then were working smoothly on the East Bank.

Plant Location

The second of these was the decision to locate the new yard in Pascagoula and operate it in parallel with the existing East Bank yard The new yard would require 7,000 workers to meet its commitments in addition to the 7,000 required for the East Bank But despite heroic efforts to recruit labor locally and recruit skilled workers throughout the U S. and Canada, the East Bank yard could not be manned to meet schedule commitments, even as the LHA and subsequent total package procurement proposals were being submitted

There was just not the population base on the Gulf Coast to support even one 7,000-man yard – much less two 7,000 man yards! There was no housing for the imported labor and turnover rates were exorbitant.

The Litton facilities planners had recognized this condition and originally sited the new yard in Tampa Bay, Florida, where there was a certifiable labor supply. The Beverly Hills financial strategists chose to ignore the Pascagoula labor problem because of the very favorable financing for the new yard featuring the free use by Litton over a ten-year period of the $130 million in funding for the yard provided by the state The manpower shortage, besides being a major factor in slowing the start-up of the new yard to schedule, contributing to massive cost overruns and later to constructive claims, led to the ultimate phase-out of the East Bank shipyard as a separate shipbuilding entity This obviously defective siting decision by Litton was either overlooked or ignored by the Navy in its analysis of Litton's first "total package procurement" proposal (for the FDL). It was to cost the Navy dearly on subsequent Litton claims.

Litton/Erie Midbody Facility

In 1967, Litton also conceived and in 1968 built a truly unique progression-type Lake ore-boat mid-body manufacturing facility at Erie, Pennsylvania. This had a covered manufacturing and assembly shed, the final assembly portion of which covered the head of a floodable building dock. It was part of a grand scheme to exploit the opportunity Litton perceived to be opening up for very large pelletized ore carriers by virtue of the newly constructed Poe Lock between Lake Michigan and Lake Superior at Sault Ste. Marie, Michigan This new lock would allow the passage of ore boats of at least 105 ft. beam and lengths up to 1005 ft. or more – with attendant doubling or more of dead weight capacities. Litton settled on a ship 1000 ft LOA, beam 105 ft and cargo capabilities of 52,000 tons The largest laker built up to that time had been the 26,000 DWT ARTHUR B HOMER.

The principal unique feature of the facility was a final assembly jig located under cover at the head of the building dock in which the 17 identical 500-ton midbody units could be, in series, assembled and welded together in such a manner that the hull seams were welded vertically in one pass by the AVA, electrogas process. After completion of all welding, each unit was then rotated 90 degrees by hydraulic jacks and joined to the previously completed unit assembly.

The ships' bows and sterns were planned for construction at Litton's existing Pascagoula yard, sailing under their own power to Erie, where they were to be joined.

The manufacturing concept and jig design were the work of a bona fide aircraft manufacturing genius, the late Richard A Myers, who could and did respect the differences in the nature of the product between ships and aircraft. The facilities planning and the ship design were done concurrently The Cleveland-based naval architects, Marine Consultants and Designers, did the latter The result was a ship design which supported the facility's intrinsic capability of constructing midbodies for 15 man-hours per ton [8].

The Bethlehem Steel Corporation contracted to buy the first vessel and held options for several follow-on ships Unfortunately, due to inept management of the yard itself and of the "Litton Great Lakes" operating company, of which the yard was a component, the first vessel, STEWART J. CORT, was delivered 17 months late and at a cost exceeding the budget by several times. Litton subsequently built for its own account the tug-barge combination PRESQUE ISLE, delivered in December 1973, but then closed the yard down. No follow-on ships were built for Bethlehem at Erie, although even today the CORT is considered the "Cadillac" of the Great Lakes ore fleet.

The boom in large ore boat construction which Litton had anticipated finally came several years later – but with the ships being built in other yards.

Revamping of the General Dynamics/ Quincy Yard for LNG Construction

See *Concurrent Planning and Engineering of the Quincy 125,000 Cubic Meter LNG Carriers [Circa 1970–1972]*, page 24

Revamped Electric Boat Submarine Construction Facilities

In 1973, Electric Boat through the innovative modernization of its Groton facility and the concurrent establishment of a modern submarine hull manufacturing facility in the abandoned naval air station at Quonset Point, Rhode Island, created the equivalent of a brand new shipyard suitable for simultaneously building both the 688 class of attack submarines and the much larger TRIDENT class SSBNs. The Quonset Point facility automated frame and hull cylinder manufacturing to a remarkable

degree and provided for preoutfitting of the completed hull cylinders. Special attention was given to making all hull attachments prior to blasting and painting – always a basic criterion for efficient ship construction and particularly important with modern alloy steels and coatings. Preoutfitting is now reported to be 85 percent complete in each cylinder or module before it leaves Quonset Point by barge for Groton.

The Groton revamping created a covered-land, level assembly system, a hull transfer system and a floodable lift dock or "pontoon" for final outfitting, launching and retrieval of finished ship hulls. It is of interest that the pontoon system was developed and installed only after ADM Rickover had vetoed the use of a Synchrolift installation which, according to the facility's designer, Richard Salzer, would have been simpler and less expensive. Salzer and Wood have given a comprehensive description of the facility [9].

Newport News Facilities Improvements

In 1974, Newport News augmented its existing yard with large building basins with a view toward building up the commercial segment of their business. VLCCs and LNGs were assembled therein. More recently they created a preoutfitting shed for submarine hull cylinders and a land-level assembly system which translates the completed submarines endwise onto a grounded pontoon for launching.

Ship Launching and Retrieval Systems

While traditional greased launching ways have continued to be used effectively for the construction and launching (both end and side launching) of small ships during the last 50 years, other, more cost effective systems have largely supplanted them in the planning of new shipyards and the modernization of existing yards. The same may also be said with respect to the use of marine railways in retrieving vessels for underbody work [10].

For larger ships, building basins such as were used in two WWII "emergency" yards (the South Portland Shipbuilding Corporation and the Kaiser/Richmond, California, yard) have become the norm. These docks, depending on their depth, can be used for both new construction and repair/overhaul. Examples of such multiple-use docks go back for at least two centuries. On the Great Lakes such docks have been used for the construction and maintenance of the Great Lakes ore boat fleet since the 1880s. Other earlier examples in the U.S. are located in the naval shipyards.

Post-WWII examples are the building basins built to facilitate series tanker construction at the Bethlehem yard in Quincy, Massachusetts, in the 1950s and the docks or basins built at both Sparrows Point and Newport News in the 1970s in anticipation of a U.S. VLCC construction program. Also starting in the 1950s and 1960s, building basins became integral parts of progression assembly yards in both Europe and Asia.

At the low end of the range, the mobile and easily maneuvered, self-propelled "travellift" has become the clearly superior and cost effective system to launch and retrieve vessels of up to 150 tons docking weight.

As reported by Richard Salzer, between 150 and 24,000 tons docking weight and, starting in the mid-1950s, the proprietary SYNCHROLIFT, invented by naval architect, Raymond Pearlson, has come increasingly into use [11]. The first installation was at the Merrill-Steven shipyard in Miami in the mid-1950s. The key element of his invention is an AC synchronous induction motor which operates at one speed regardless of the load. Thus an infinite number of synchronous induction motors operating from the same power source will perform exactly as if they were mechanically coupled. This, combined with the concept of an articulate platform to simulate the buoyant forces applied to the ship's hull in the water, make it practical to apply the concept to larger ships' hulls without introducing point loads on the hull. While the synchrolift requires the construction of suitable load-bearing piers and bulkheading, the system has obvious cost, reliability, operational, and maintenance advantages over dry docks or graving docks for both new construction and repair work in the same land-level shipyard and with a minimal intrusion on the waterfront as compared with multiple shipways or building basins.

A synchrolift of 22,000-ton capacity has been in operation since 1985 in the Los Angeles, California, yard of the Todd Pacific Shipyards Corporation. The Vickers yard at Barrow in Furness, England, has a synchrolift of 24,000 tons capacity as part of a nuclear submarine facility very similar to the modernized GD yard at Groton, Connecticut. Synchrolifts of 40,000-ton capacity (for ships up to 120,000 DWT) are considered feasible.

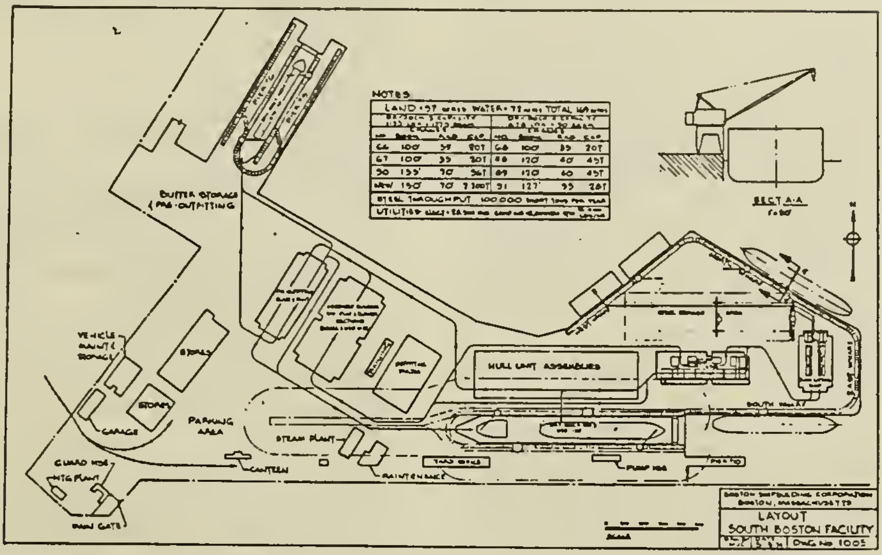
Floating drydocks continue to be very effective in repair yards, and when used in conjunction with grounding pads, can be used as the launching system for ships of any tonnage as illustrated by the Electric Boat and Newport News "lift docks."

Boston Shipbuilding Corporation

Concerned by the shutdown of the Boston Naval Shipyard and the loss of several thousand blue collar jobs in the city, the First National Bank of Boston asked this writer, in 1973, if I would look at the validity of the shipyard (including both the Charlestown yard and the South Boston Annex (circa WWI), which included several manufacturing buildings, a 1150-foot dock, and two smaller building docks) for use in commercial shipbuilding. I found the South Boston yard ideal for serial construction of tankers of up to 120,000 DWT, and the Charlestown yard's machine shop nearly ideal for the manufacture of slow-speed diesels. J. J. Henry and others in the industry confirmed my findings. I was then asked by the City of Boston if I would form a company to build ships in the yard(s). This I agreed to do on the condition that it would be a venture backed by a broad spectrum of the Boston business and financial community, including the four leading banks. This was done, and \$250,000 in seed money was provided. Market analysis by Prof. Henry Marcus of MIT confirmed that we should shoot to exploit the market for smaller ships, and this we did. We obtained a license from NASSCO for the use of their CORONADO class tanker design, and Al Bates converted the engine room plans to accommodate a Sulzer slow-speed diesel. We then worked out a joint venture with Sulzer Brothers to manufacture a line of slow-speed diesels in the Charlestown yard, with Sulzer to exercise technical control thereof. Sulzer was also to contribute to the working capital of the yard. With this on hand, we could and did obtain a letter of intent contract from three shipowners for a total of 10 U.S.-flag, 38,800 DWT tankers. In the meantime, the city arranged the purchase of the two yards from the government for a nominal sum, and we negotiated the terms of a long-term lease with the city. With the letter contracts for ships in hand and the assurances that the city would sign the lease, we were able to obtain contingent commitments for the necessary financing: \$26 million for new facilities and equipment, as worked out by Jen Furst, and \$7 million for start-up costs. Negotiations were well underway for construction of additional ships, including a series of 100 handy- sized tankers for a consortium of Norwegian owners.

As 1974 progressed, the city found one excuse or another to not sign the lease. No plausible reason was given. The (not so

Figure 7. Boston Shipbuilding Corporation, South Boston Yard (former Boston Naval Shipyard Annex)



secret) secret reason was that General Dynamics had somehow induced the city to give it an option on the South Boston yard so it could be used on leverage to force the LNG sphere contractor, Pittsburgh-Des Moines, to relinquish the sphere manufacture to GD By January 1975, our letter contracts had expired GD by then had successfully broken its contract with Pittsburgh-Des Moines The city then expressed interest in signing the lease However, President Ford had effected his pocket veto of the Cargo Preference Act of 1974 With that, the prospect of a bright market for U.S -built VLCCs vanished, and with it (illogically) the prospects of reviving our venture to build smaller tankers As a byproduct, it foreclosed the prospect of manufacturing slow-speed diesels in the U.S., and of course the U.S lost another extraordinarily fine shipbuilding facility. Perhaps saddest of all, the prospect of putting 7,000 blacks and South Boston Irish happily to work in the shipyard, instead of warring in the streets, vanished.

Submarine Design and Construction, 1943–1993

Introduction

WWII submarine construction was a story of series production In the years 1940–1945 (inclusive) 223 basically similar submarines were delivered from the two lead yards – Electric Boat and Portsmouth, and three follow yards, Mare Island, Manitowoc and Cramp Lack of reliable diesel engines in support of projected schedules seriously hampered production, particularly at Cramp – the last yard into the program In the five years following VJ day the war time production was quickly phased out of both lead and follow yards. A low-key effort of experimental work – guppy conversions and optimized WWII designs such as TRIGGER TROUT and HARDER – was maintained at Portsmouth and to some extent at Electric Boat, but by 1950 the work force at the Electric Boat Company was down to less than 700 in the yard, 100 in design and five graduate engineers of any kind on the premises

The Revolutionary Decade, 1950–1960

In 1950 two revolutionary projects were initiated which were to trigger unprecedented developments in submarine design and construction. These were the BuShips nuclear power program and the ALBACORE project, which incorporated in an experimental submarine a single propeller behind a teardrop or "body of revolution" hull. The first of these developments would allow Navy planners to hypothesize almost infinite underwater operations, and the second would allow previously undreamed-of underwater speeds in the range of 40–50 knots. When these two features were combined in the EB-designed and built SKIPJACK, delivered in 1958, it was hailed as the first true submersible.

In 1950 then-CAPT Rickover asked Electric Boat to undertake the design and construction of two land-based power plant prototypes; one incorporating a Westinghouse pressurized water reactor (STR) and the other a General Electric sodium cooled reactor (SIR). Development of these reactors had been previously been commenced under the auspices of the Atomic Energy Commission, the Naval Reactors Branch of which Rickover headed with his "second hat" on. Their operational tests and evaluation of results were prerequisite to the design and construction of seagoing vessels NAUTILUS and SEAWOLF, which were almost immediately authorized and followed closely thereafter. Also to EB fell the task of coordinating with the major contractors the simultaneous reactor plant development and manufacturing schedules in support of the ship construction schedules. [This writer, personally, had collateral duty to teach

Rickover's AEC staff, Westinghouse, and GE the basic elements of planning and executing large development projects]

After extensive tank testing, the Navy carried out the ALBACORE design and construction at the Portsmouth Naval Shipyard, and she was put in service in 1953 The results of this testing were used in the design of SKIPJACK, which commenced in 1955. The ship when delivered in 1958 was hailed as the world's first true submersible.

But that was not all In late December 1957, in answer to the perceived Soviet ICBM threat, a third and, perhaps, even more revolutionary project was conceived and "launched" under the direction of the Navy's Special Projects Office headed by RAdm "Red" Raborn. It was assigned the government's highest priority – BRICKBAT The concept was to incorporate into a lengthened SKIPJACK class hull several long-range and yet-to-be-proven solid-propellant missiles to be launched under water. The ship was to be navigated underwater with an inertial navigation system – the brain storm of MIT's Stark Draper Electric Boat was asked on December 30, 1957 to undertake the ship's project for delivery 24 months later (It was – to the day!) The ship was to be capable of "firing missiles in anger" six months later (This also would occur to the day!)

As comprehensive as the 1950 reactor development program was, and would later become, it was dwarfed by the size and compression of the development schedules for the development from concept to hardware of the as-yet unproved components of the total POLARIS system; the solid propellant missile, the ship's inertial navigation system, the fire control system and the launching and handling system, as well as the submarine itself. The latter would embrace and integrate them all. At the December 30, 1957, meeting in Washington at which EB agreed to undertake the POLARIS program, RAdm Raborn delegated to Electric Boat, and specifically to the writer, the responsibility for setting the schedules of requirements against all of the government's contractors that were to develop and furnish program-related hardware and software. The manner in which this responsibility was discharged is discussed under management systems

Sandwiched between these major submarine development projects undertaken and completed between 1950 and 1960 were

- The EB-designed and built SKATE, an experimental prototype which was also the first of a class.
- The bulk of the work on the Portsmouth-designed and built THRESHER, which was to have been the lead ship for more than 60 attack submarines until its loss on Sea Trials in 1960.
- TULLIBEE, another EB experimental prototype.

The basic parameters of these and other nuclear prototypes, experimental submarines, and/or "first of a class" submarines built in the period 1950–1993 are shown in Table 2. Examination thereof will confirm that nearly 50 percent of the entire period's experimental and prototype vessels were designed and constructed in the first decade, 1950–1960, and all but one of these at Electric Boat.

Specific Engineering Challenges, 1950–1960

Some of the specific development engineering and construction challenges which were met at EB in that first decade are tabulated below:

- Mechanisms and control systems for quadrupled underwater speed
- Doubled hydraulic pressures (all-new components had to be developed)
- HY80 steel and control of the welding process to avoid delayed cracking
- All-welded sea water systems
- Flexure in piping
- Sound attenuation and shock requirements
- Custom versus standard pipe hangers to meet the above three requirements
- Order of magnitude improvement in underwater environmental systems, specifically in habitability and air conditioning for six-month cruises w/o surfacing [an exponential increase in requirements]
- Introduction of a reactor plant into a submersible (exponential increase in requirements)
- Development of effective radiation shielding
- Steam propulsion plants vs diesel
- Growth in number of weapons systems and almost exponential growth in their size and complexity
- Exponential growth in Quality Assurance measures required
- Engineering and qualification of sea valves and connections for doubled submergence
- Proliferation of design arrangement problems because of the high "packing fractions" in all compartments of the rapidly evolving modern submarines

The manner in which these challenges were met is discussed in the sections dealing with "Shipyard Management Systems & Methods" and "Quality Assurance."

Changes in Basic Submarine Characteristics

Table 2 shows how some basic characteristics have changed over the 50-year period from WWII together with spantimes from ship authorization to delivery and of man-hours for design and construction as a measure of real cost. In summary:

Displacements (submerged) have increased from 2400 tons in WWII to 9011 for the SEAWOLF class (1989) and 18,000 for the OHIO ballistic missile class (1974–1993)

Shaft Horse Powers have increased from 5400 in WWII to 15000 for NAUTILUS (1952), 30,000 on two shafts for TRITON (1956), 35,000 on one shaft for LOS ANGELES (1970) and 60,000 on OHIO (1974). SEAWOLF will have approximately 45,000 HP on one shaft

Submergence Depths increased from 400 feet in WWII to 700 feet for NAUTILUS, an attempted 1400 feet for THRESHER (1957) and its final achievement on the ETHAN ALLEN (1959) and STURGEON (1967) classes

Submerged Speeds have increased from 8–9 knots in WWII to over 40 knots on SKIPJACK, greater than 20 knots on OHIO and up around 40 knots again on the larger attack submarines LOS ANGELES and SEAWOLF

Ship contained systems, including weapons, navigation, fire control, sonar, ventilation and air conditioning (but not propulsion plant controls, which have remained manned for good reason) have increased in numbers, complexity and sophistication by orders of magnitude

Construction man-hours have increased from 1.2 million in WWII to 6 million for NAUTILUS, about 4 million for THRESHER and GEORGE WASHINGTON, to 13 million for

Table 3. 1950–1993, Nuclear propelled combatant submarines, prototype and first of class.

1950–1993, Nuclear Propelled Combatant Submarines, Prototype and First of Class

Type & No.	Name	Expt'l	Prototype	1st of Class	Design Yard	Construction Yard	Dates: Year Authorized	Dates: Contract	Dates: Year Delivered	Dates: Months Contract to Delivery	Basic Characteristics: Length (ft.)	Displacement	SHP (000)	Submerged Speed (K)	Dive Depth (ft.)	Man Hours ($\times 10^6$): Design	Man Hours ($\times 10^6$): Const'n	Total Number Built or (Projected) 1950-1993	Comments
WWII Fleet	'Bench Mark'	—	—	—	—	—								8-9	400	0.24	1.2		Diesel/Battery 223 built during WWII
Land-Based Nuclear Prototypes	STR	✓	✓	—	EB	EB	'50		'53	NA	—	—	15	—	—	NA	NA	1	Power plant only (PW)
	SIR	✓	3	—	EB	EB	NA	NA	NA	NA	—	—	15	—	—	NA	NA	1	Power plant only (Sodium)
SSN-571	*Nautilus*	✓	✓	—	EB	EB	'52?		'54	44	320	4,100	15		?	1.5	6?	1	Pressurized water reactor
575	*Seawolf*	✓	✓	—	EB	EB	'53		'57		337	4,300	15		?	NA	NA	1	Sodium-cooled reactor
578	*Skate*	✓	✓	✓	EB	EB	'55		'57	29	268	2,800	?			NA	3	4	
585	*Skipjack*	✓	✓	✓	EB	EB	'56		'58	42	252	3,500	15	>40	700	NA	3.5	6	"First true submarine"
586	*Triton*	✓	✓	—	EB	EB	'56		'58		447	6,670	30			NA	NA	1	Two PW reactors/twin screws
593	*Thresher*	—	✓	✓	PNS	PNS	'57		'60	?	279	4,300	15	>30	1,400	NA	4	1	Lost on trials
594	*Permit*	—	—	✓	*	MI	'58		'61		279	4,300	15		†	NA	3.2	9	Ports design modified by EB for Subsafe
597	*Tullibee*	✓	✓	—	EB	EB	'58		'60		273	2,640	?	20		NA	NA	1	Electric drive, anti-sub opn s/Bow SONAR
SSBN-598	*George Washington*	✓	✓	✓	EB	EB	'57	'57	'59	24	382	6,700	15		700	2	4+?	5	
608	*Ethan Allen*	—	—	✓	EB	EB	'59		'61		608	7,900	15		1,400	NA	NA	5	Lengthened 598
616	*Lafayette*	—	—	✓	EB	EB	'61		'63	32	425	8,250	15	25	1,400?	2	4	31	Complete redesign
SSN-613	*Flasher*	—	—	✓	EB	EB	'60		'63		292	4,300	15		?	NA	2.7	3	"Quick" EB redesign of *Thresher*
637	*Sturgeon*	—	—	✓	EB	EB	'62		'67		292	4,800	15		1,400?	NA	NA	27	Complete EB redesign of *Thresher*
671	*Narwhal*	✓	✓	—	EB	EB	'64		'67		314	5,800	15			NA	NA	1	Direct drive turbine
678	*Archer Fish*	—	—	✓	EB	EB	'67		'71		300	4,970	15			NA	NA	6	Lengthened 637
685	*Lipscomb*	✓	✓	—	EB	EB	'68		'73		365	6,480				NA	NA	1	Turbo electric drive
688	*Los Angeles*	—	—	✓	NN	NN	'70		'74	72	360	6,927	35		1,475	NA	NA	49 (13)	Large power plant/1 screw
SSBN-726	*Ohio*	—	—	✓	EB	EB	'74		'81	84	560	18,000	60	>20	984	NA	13	12 (6)	Large power plant/1 screw
SSN-21	*Seawolf*	—	—	✓	EB/NN	EB	'89		(5/95)	80	353	9,100	±45			NA	(10)?	1 (2)	Large power plant/1 screw
																		165 (21) 186 + (?) more Seawolfs	

Sources:
- "U.S. Navy Nuclear Submarine Line-Up," EB 3/93
- *Jane's Fighting Ships*
- Private Sources

NA = Not Available
† Restricted

the OHIO (SSBN) class. and a projected 10 million for the SEAWOLF attack class

Design and construction span times which got as low as 29 months on SSN 578, SKATE and 24 months on SSBN 598, GEORGE WASHINGTON, grew to 72 months on SSN 688, LOS ANGELES and 84 months on SSBN 726, OHIO. The span time will be at least 80 months for SSN-21, SEAWOLF.

A substantial part of the order of magnitude increase in construction man-hours and the three- to four-fold increase in design and construction lead times can be attributed to the increased scope of the work which came with changes in the Navy-specified ship characteristics and parameters. The balance has to do with changes in the Navy ship procurement organization, which have not always been for the better, political pressures exerted on the Navy, "politicking" within the Navy, the effect within the construction yards of overhaul work and retrofit programs, such as for the POSEIDON missiles in the earlier SSBNs, and relative loss of control within and between the submarine design and construction yards themselves and with the Navy. The above factors will be discussed further in the section on "Shipyard Management Systems & Methods."

Quality Assurance

Introduction

The term "Quality Assurance" was unknown in shipbuilding at the start of the post-WWII era although most shipyard organization charts showed an "inspection" or "quality control" function somewhere thereon. The larger yards had welding engineers and welding procedures which had to be followed. At Bethlehem's Quincy yard, Paul Ffield introduced an early example of enlightened "Quality Assurance" when he pioneered the X-ray of steel castings to spot defects before they were expensively uncovered in the machining process. Commercial yards had owners' representatives and regulatory body inspectors (ABS) in residence. In fact, the predecessor organization of ABS, the American Shipmasters' Association, had been founded in 1862 for the very purpose of assuring sufficient quality in ships' hulls and other component parts, particularly boilers, so that losses at sea of ships, their cargo and crew would be minimized ("Safety at Sea"). On Navy work SupShip's staffs included uniformed inspection officers and supporting inspectors. Shipyard inspections, however, tended to be of the finished product, which engendered much rework. In the plants of major marine equipment suppliers there were resident "Inspectors of Naval Material" (INM) with their famous anchor stamp whose "in process" inspections did much to assure quality of the components supplied to shipyards. Where naval and commercial products such as gears and turbines were coming down the same assembly lines, the quality of both benefited from the presence of the INM inspectors. On the material side, certificates of compliance to specification were required for the more exotic metals and alloys used in shipbuilding – a requirement often honored in the breach thereof.

This state of affairs dramatically changed in naval shipbuilding in the 1950s as a function of six events:

- Commencement of the Navy's nuclear power program in 1950
- The NAUTILUS pipe incident in 1954
- The introduction of HY 80 to submarine hull construction in 1955
- The requirement to double the submergence depth of the THRESHER class submarine in 1957 and its subsequent loss in 1960.
- The appointment of Robert MacNamara as Secretary of Defense in January 1961. (He served through February 1968.)

The Advent of Nuclear Power

Reactor plants introduced exotic materials and exacting controls over their identity and use into the submarine building yards commencing with the design and construction by Electric Boat of the land-based nuclear power plant prototypes, STR and SIR, in 1950.

The NAUTILUS Pipe Incident

In December 1954, as the NAUTILUS power plant was being tested with shore steam preparatory to activating the reactor, a small-diameter feed system pipe burst on hydrostatic test. The cause was easy to pinpoint. The line had been fabricated with welded instead of the specified seamless tubing. In accordance with long-prevailing custom, an individual tradesman had written his own requisitions for and withdrawn the tubing from stores! His requisition called merely for "steel tubing" and he happened to get welded tubing from comingled stock.

Not only did all of the steam piping in the engine room have to be replaced, but it had to be replaced with material that had a clear-cut certified pedigree and over which physical control of its identity had been exercised from the mill, through fabrication and installation in the ship. The ship was delayed 6 months at a multimillion-dollar cost to Electric Boat.

In addition, an investigation of the yard's nearly $10 million inventory of stock materials revealed that none of it could be certified as to source or compliance with specifications. It was scrapped and replaced. As a function of replacing it, major steps were taken in advancing "quality assurance" in the particular area of "control over the identity of materials." These were:

- Only seamless steel pipe allowed in the yard – regardless of end use.
- Inspection of all incoming materials on receipt and their certificates of compliance on receipt.
- Marking of the material specification continuously thereon before it went to stores (segregated in the case of nuclear materials).
- Rejection of any materials in process which did **not** have these identifying markings thereon.
- Supporting changes in the yard's storekeeping, inventory management, procurement procedures and engineering procedures to guarantee that appropriate and up-to-date material specifications were incorporated in all on purchase requisitions. Major elements of these reforms were:
  - — Standardization of material specifications.
  - — Introduction of an eight-digit nomenclature system which provided the basis for material identification from design through purchasing, warehousing, and distribution to final usage.
- Requirements for and audit of Vendor Quality control procedures.

- Tradesmen were no longer allowed to prepare store requisitions. and a validation check was made of each requisition against the appropriate plan or bill of material

Many of these reforms were later incorporated by the Navy in appropriate MIL specifications.

State-of-the-art quality assurance was introduced into Electric Boat by a team from the Fort Worth Division of CONVAIR, where it was being applied in spades to fighter aircraft throughout the engineering, design, manufacturing, and procurement process. It was a cultural shock, if ever there was one. But providently for the burgeoning nuclear submarine program at Electric Boat and elsewhere, it came at an early stage of Electric Boat's postwar renaissance. The lessons were engraved in the souls of every Electric Boat team member, including that of the writer

Elimination of Automated Controls on NAUTILUS

Another highly significant event took place just before reactor steam was scheduled to be introduced into the engine room. Rickover called up and ordered that the "automated" propulsion controls be removed They were. He was rightly concerned that a malfunction in the automated controls that he himself had specified could place the nuclear propulsion program in jeopardy Navy nuclear plants continue to be manually controlled by carefully selected officers trained in nuclear engineering to this day – thank God.

The Advent of HY80 Steel

When HY80 was specified for the hull of SKIPJACK in 1955, these hard-earned QA lessons paid off. HY80 was not only subject to lamination, but also required very careful preheating before welding to forestall delayed cracking from within the heat-affected zone, and its subsequent propagation. Extensive X-rays and auditable records thereof were required Electric Boat had learned earlier that ultrasonic testing would reveal hidden defects in brazed pipe joints It was tried on the plates as follows:

Electric Boat did ultrasonic testing of all HY80 plate by performing ultrasonic testing on the four sides of a 12-inch square and then one diagonal. Navy specs required only a spot on each corner We found many laminations that would have been missed had the Navy method been used.

As I remember, the first use of it for welds was in the reactor compartment where hull insulation would make inspection of the welds impossible after the insulation was installed Cracking was found that again did not show up on X-ray examination. Ultrasonic testing examination of plates and welds for defects became standard practice at Electric Boat, both prior to and after X-ray, as appropriate

Navy officials, informed of our findings and recommendation that ultrasonic testing be included in the MIL specs, opted not to do so because they wanted permanent records of X-rays It proved costly to them in delays and overruns because of extensive repairs required in the HY80 hulls of submarines built in other yards – where X-rays alone were made and extensive hull cracking later developed.

Formalizing of Modern Quality Assurance

In 1962 Electric Boat established the prototype for the Quality Assurance Program that is required of every yard engaged in building naval combatant ships today. The organization was headed by Oscar Goode and Jack Dallanger and was based on Electric Boat's hard-won experience. Their paper on the subject presented to the ASNE in Washington on May 1. 1964. outlined these Electric Boat principles and practices which even today, 27 years later, would meet the industry standard for a state-of-the-art Quality Assurance program [12].

Subsafe

It took the tragic loss of THRESHER in April 1963 to finally shock the Navy into the recognition that all was not well in the Quality Assurance area of submarine design and development, not only at the Design branch and Type desk in Washington, but particularly in the design process at the Portsmouth Naval Shipyard As I had discovered in WWII in the course of trying to build follow submarines to Portsmouth plans, Portsmouth's engineering controls were seriously deficient in allowing alterations to be made in shops and on the ways, often with only verbal authorization and worse, without recording the changes on the plans This did not necessarily affect the quality of the WWII submarines "as built" at Portsmouth, but it created significant problems for Cramp as a follow yard, i.e., disruption and delay!

The THRESHER, authorized in 1957 almost concurrently with the GEORGE WASHINGTON, and also targeted for expedited delivery, was allowed to proceed on the basis of a doubled submergence depth despite Electric Boat's having stopped it with respect to GEORGE WASHINGTON when we pointed out that a multiyear development and testing of sea valves and connections for the increased pressure would be an absolute prerequisite for safe operations at 1400′ submergence, and that this would preclude delivery of the GEORGE WASHINGTON in December 1969 as desired.

Electric Boat had in the meantime found, as a follow yard to Portsmouth on the THRESHER-class program, that the Portsmouth plans were so deficient from a producibility aspect, including specifications for material to be used, that we unilaterally decided to rework them completely before releasing them to the yard.

Subsequent to the THRESHER loss, Electric Boat was officially authorized to complete the reworking of the THRESHER plans to SUBSAFE standards, first for use in finishing the nine ships of the THRESHER/ permit class that were already started – but with depth-restricted operations, then a further effort to improve the Portsmouth design including its lengthening for 3 ships of the PERMIT class; then a complete redesign including even more added length – resulting in the STURGEON class of 27 submarines; and finally with the ARCHERFISH class of 9 ships in which even more length was added.

The SUBSAFE program had the stated objective of recertifying all of the Navy's submarines to operate at their test depths. The remedial measures, which included many initiated earlier at Electric Boat, were subsequently incorporated into specifications.

MacNamara Influence on Quality Assurance

It is an ill wind indeed that blows no good and this must also be admitted to be the case with respect to MacNamara and his effect on naval ship design and construction. His largely "successful" dismantling of BuShip's command over the preliminary and contract design process, and thus basic control over the scope of that which they contracted out for construction, was disastrous, and the Navy has never recovered from that ill-conceived blow. The "Total Package Procurement" concept was also a costly disaster. But his forcing the adoption in naval shipbuilding of Quality Assurance Specifications – MIL Q 9858 A and MIL I 45208 A – derived from aircraft industry practice

was to prove a saving grace when the application of these specifications was made obligatory as part of contract terms and conditions.

The Ingalls Quality Assurance Turnaround

When I went to Ingalls in 1967 to "turn it around" and, among other things, restore it to the Navy's Qualified Products List as a prerequisite to further bidding on naval work, I found that Ingalls had engaged a retired Navy captain to resist and challenge every aspect of these specifications, perhaps with dollar claims in mind. He was doing it with gusto! On reading the above-referenced QA MIL Specs, I found them to contain the very essence of quality assurance practices which we at Electric Boat had adopted under stress following the NAUTILUS pipe incident, and which in the decade that followed contributed so importantly to Electric Boat's record for quality ships designed, built and delivered to tight schedules on time. Therefore on becoming the Ingalls general manager in 1967, I simply turned QA policy at Ingalls by 180 degrees. Under the leadership of a brilliant former Navy constructor, retired RAdm Floyd Schultz, Ingalls prepared, and put into practice practically overnight, a Quality Assurance Manual, and procedures. We then applied them across the board in completing a large backlog of naval and commercial ships which cluttered the yard. This was of equal importance to gaining schedule discipline throughout the yard and resulted in the first two vessels, a submarine and LSD, presented for acceptance to ADM John Buckeley, the Navy's new President of the Board of Inspection and Survey, being accepted when they were first presented therefor – both on the same day! He had previously turned down all ships presented by every other yard building naval ships, including the JOHN F. KENNEDY at Newport News. Ingalls soon returned to the Navy's qualified products list!

ADM Buckeley's contribution to shipbuilding quality and operational readiness and his combat exploits have been documented elsewhere. I cite it here as an example of what consistent inspired leadership by a true leader can do in achieving a goal – in this case the quality of ships delivered to the Navy. He was to be in command of the Naval Board of Inspection and Survey (INSURV) for a total of 21 years, many of them after mandatory retirement age! He first had to select, indoctrinate, and inspire a new staff to judge the product objectively and to established standards. Where adequate standards did not exist, he saw that those responsible created them. He made it a point to know the men responsible in each yard for the design and construction of the ships presented to his organization. His critiques were formal, invoked the proud traditions of the Navy and naval shipbuilders, and were salty and laced with subtle humor. When he turned down a ship, he identified specifics. Where praise was in order, he specifically identified those responsible by name. On successive ships of the same class, he identified the improvements made in reducing "UNSATS." As a shipyard manager I could measure the beneficial effect that his successive critiques had on the yard supervisors responsible. Men love to be recognized whether praised or constructively criticized. He did the same in his periodic inspections of ships in commission. Adroitly avoiding reorganization plans that would have "defanged" INSERV, he laid the basis for much of what was to be systematically developed over the years to keep the fleet in ever improved state of readiness. We shipbuilders were lucky indeed to win the appreciative friendship of a man like that. The U.S. defense posture was also a clear winner!

Concurrent Planning and Engineering of the Quincy 125,000 Cubic Meter LNG Carriers [Circa 1970–1972]

Background

In the spring of 1970, at a shipbuilders' council meeting in Newport News, Virginia, RAdm Nathan Sonenshein advised the shipyard chief executives assembled there that henceforth all naval auxiliary vessels would be built in series in large lots at no more than three yards–as opposed to dividing them into smaller lots to be bid on by a larger number of yards. The General Dynamics Quincy Yard and the Bethlehem Sparrows Point Yards were among those given their pink slips, so to speak. The naval combat shipbuilding program had already been concentrated in fewer yards as a function of "Total Package Procurement."

If the General Dynamics/Quincy yard was to remain in business, we had to develop our own opportunities. We at the yard thought we could. Col. Crown, the controlling General Dynamics stockholder, and President David Lewis were less sure. Nevertheless, I established several criteria for a suitable product:

- It had to be proprietary.
- It had to serve an as yet unexploited market and be one that we could corner if we worked at it.
- It had to have a high level of technical sophistication that would, if possible, take advantage of General Dynamics knowledge in its aerospace divisions.
- It had to be capable of development on a fast-paced time schedule.

An in-depth investigation developed the probability that the world market for LNG carriers was about to expand substantially. LNG ships met the first three of the above criteria perfectly, but the tight timing meant we could not start from scratch in the development of our own containment system.

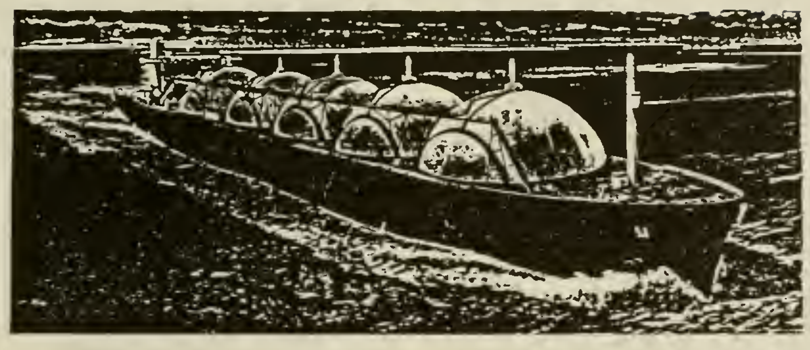
We selected the proprietary Kvaerner-Moss spherical tank system after exhaustive study of all alternative concepts, most particularly with respect to the ultimate safe containment of the cargo in every conceivable disaster scenario, for we were dealing with one of the world's most hazardous cargos in the event it was ignited. The provisions for double hulls and spherical containment offered the best probability of avoiding disaster in the event of collisions and groundings.

Further, Kvaerner-Moss already had a research, development, and ship design project underway for a 77,000 cubic meter ship employing nickel steel tanks. We obtained an exclusive worldwide license to market the spherical tank ships in capacities of 120,000 cubic meters and above, and, somewhat surprisingly, convinced the corporate office of General Dynamics to fund the development.

"The Skunk Works"

Taking a leaf out of aircraft design practice, we immediately established a "skunk works," a dedicated area wherein all of the ship planning, scheduling, facilities engineering, ship engineering and design, production engineering, facilities planning, tooling, and quality assurance engineering was done "concurrently." The essentials of concurrent engineering had, of course, been applied from the early 1950s onward to submarine design at Electric Boat. "Concurrent Engineering: Total Quality Management in Design," [13] is an excellent recent paper on

Figure 8. Principal characteristics of the 120,000 m³ Quincy LNG carrier ship as conceived in 1970



Length overall	924'-0"	Deadweight	61,100 L.T.
Length on 36-foot draft waterline	885'-0"	Cargo tank volume @ −265°F	121,800 m^3
Beam	141'-6"	LNG capacity @ 99.5% and −265°F	120,000 m^3
Depth	82'-0"	Shaft horsepower	40,000
Draft	36'-0"	Maximum speed	20 kt
Displacement	91,200 L.T.	Loading or unloading time	12 hrs.

the subject. The Quincy effort was originally headed by Richard A. Myers, who reported directly to me. He once again came up with a brilliant and comprehensive manufacturing plan which advanced the state of the art for the ship and created the world industry state of the art for designing and manufacturing the LNG containment spheres ("120,000 m3 LNG Ship Manufacturing Plan," 1971). The manufacturing plan [14] was the integration and control document for all aspects of the planning and engineering. It was updated and reissued periodically. When Myers left the project at the end of 1970, I was able to induce Taylor Medalist Douglas C. MacMillan to come out of retirement. As my deputy he exercised overall technical control. Other SNAME members who were major factors in the project's success were Jack Dallinger, Director of Engineering, Alan Donkin, Naval Architect and later Project Director (ship design and producibility), Robert C. Eddy, quality assurance (development and qualification of fully automated procedures for welding and inspection of the aluminum spheres), Rolf Glasfeld, head of sphere design (the first design using finite element analysis of a large structure in this country! It was also used to advantage in design of the ship's hull.), and John Randall, Director of Planning.

One of the first preliminary design tasks was to decide the number and size of the spherical LNG containment tanks. We decided on five tanks of 24,000 cubic meters (later changed to 25,000 CM). With that settled, the matter of the tank material was addressed. The nickel steel being used for containment in the smaller Norwegian vessels was unavailable in the U.S. due to an acute nickel shortage. Casting about for available alternatives, we consulted our corporate cousins, the Convair Division of General Dynamics, who at the time were building Atlas rockets in San Diego. They recommended 5083 aluminum, a truly wonderful material (I love it!) whose ductibility increases as the temperature decreases to the −273°F of liquefied natural gas. It was also easily hot worked (to taper the plating), weldable and X-rayable by automatic means. Before committing our ship design to it and the safety of the cargo – we designed and then made and tested every joint exactly as it would be made in the finished spheres, including the all-important equatorial "ring" – where the aluminum sphere would be joined to its supporting cylindrical bulkhead using the equipment we would use in production. In this case, and after having created a defect of the "ring" therein, we tested it in Alcoa's cryogenic test facility with cyclical application of stresses simulating the forces that would be seen by it in "winter – North Atlantic." This was under the "leak before failure theory." After "30 years" of such cycling, the crack did not propagate, so we increased the stresses to approximate the loads that would be experienced in hurricane-created seas. Eureka! The crack did start to propagate after 30 years of cycling but at such a rate that it would not require repair for another 30 years! We could and did then proceed with the design and worldwide marketing process with a high degree of confidence. Since the sphere design represented the first application of "finite element analysis" in U.S. shipbuilding, part of our engineering effort was devoted to educating the regulatory bodies ABS and the U.S. Coast Guard in the theory and techniques involved and exposing them to the results of Norske Veritas experiments as well as our own.

Figure 9. Self-aligning method of assembling stiffened panels into unit assemblies (bottom and side shells).

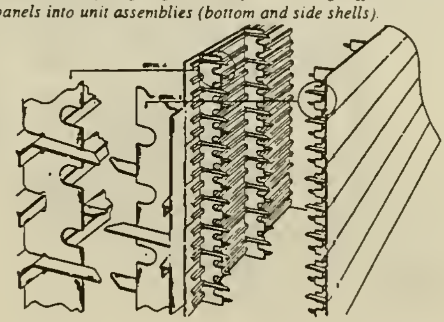


Figure 10. Structural details

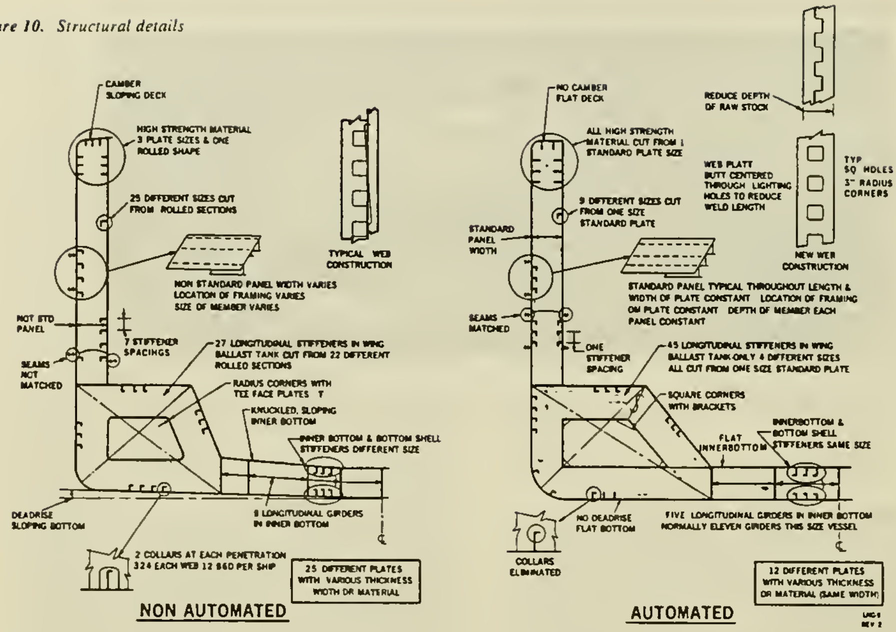
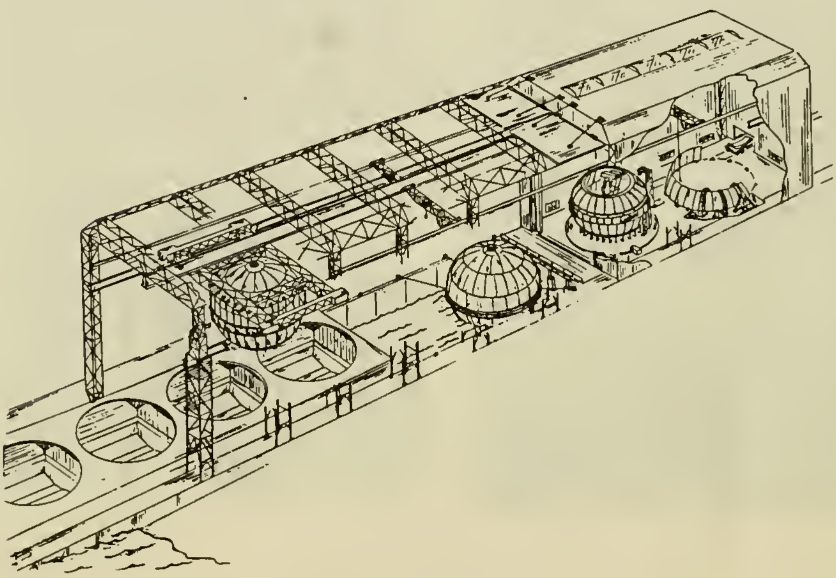


Figure 11. Sphere assembly, storage & installation facility.



The revamped shipyard layout, work flow, and equipment, including what at the time was considered the most advanced panel line in the world, were tailored to process flow sheets embracing each operation in the manufacture and assembly of the structured components of a double-hulled ship with spherical containment of the LNG. Major design emphasis was placed on standardization of parts and plate sizes, maximum use of automatic and semi-automatic welding, the use of state-of-the-art tooling and equipment, and the inclusion of quality assurance provisions in the plans, process procedures and procurement specifications. A particularly notable hull construction design advance can be seen by study of Figure 10. Standard plates were used throughout the structure, including the shapes! The steel mill's "bane," "plan & mark" material, was completely eliminated, with important economics in cost and procurement lead time.

As a result of this all-out effort, the budgeted or "standard" costs for the ship's hull as a whole equated to less than 20 man-hours/ton – less than half the cost of single-hull tanker steel work for similarly sized ships.

The bow, stern, and deck house modules were to be assembled in existing building basins. The midbody unit assemblies were to be incorporated into modules at the head of existing ways and then "launched" down on the grease and joined to make the completed midbodies. The midbodies, in turn, would be launched into the wet basin and joined to the bow and stern modules in the building basins.

The five 25,000 cubic meter LNG containment spheres of 8083 aluminum – the "scantlings" for which were developed by finite element analysis – were so engineered that all welds could be made automatically as well as their radiography. All-welded joints were made up and tested in the laboratory using the same equipment which was planned for use in production before finalizing joint designs and tooling details and vice versa. The spheres were to be fabricated and assembled in the Quincy yard's former turret shop, the completed spheres being loaded aboard ship by bridge cranes which spanned a wet basin adjacent to the shop and the planned final assembly station for spheres at the head of the ways.

This was the plan, at least, until General Dynamics President David Lewis, insisting that there had to be a spread of "potential liability," and, despite my strenuous objections, ordered the spheres to be subcontracted. This was an expensive decision to implement and even more expensive for General Dynamics to subsequently reverse.

The original manufacturing plan would have entailed a total incremental investment in facilities of $8 million, fully amortized over the first 8 ships constructed. General Dynamics, after it had reversed its subcontract decision, bought up the sphere subcontractor's plant in South Carolina and ended up investing about $200 million in foreign-designed and built sphere manufacturing equipment and tooling for the sphere plant, a transportation barge, a "Goliath" crane for installing the spheres, and substitution of building basins for the construction of midbodies in lieu of perfectly usable and efficient inclined ways. Of the $200 million, it is probable that at least 10 percent of it ended up in the form of kickbacks made to the General Dynamics general manager who engineered these entirely frivolous expenditures.

Despite these and other unnecessary increases in the cost basis for the ships, they were when finally built, and they continue to be, regarded as the most cost effective and reliable LNG carriers in the world; they were also the most profitable contract General Dynamics ever had, if the word of David Lewis can be taken as the truth in this instance.

One of the basic planning functions was brought into the skunk works at some risk, for it departed from the previous best practice at leading U.S. shipyards such as Newport News and Electric Boat. This was to bring the detail shop (process) planning – a basic prerogative of the shops doing the work – into partnership and concurrence with the design effort.

This concurrence had been attempted at the Hog Island shipyard in WWI when the four basic and sacred elements of scientific planning, "*What, when, where and how*," had all been attempted centrally. It had also been attempted by the naval yards and at Cramp early in WWII. In the latter case, I had been instrumental in putting the *how* back in the shops – as described elsewhere. But at Quincy by 1970, the decentralized process planning effort had gone importantly awry as the capability of middle management and its supporting infrastructure atrophied and lost its focus, first under Bethlehem as they lost interest in shipbuilding at corporate level, and then under less than qualified top management installed by General Dynamics.

I reasoned that if the "*how*" could be cast in concrete at the preliminary design stage along with the *what, where* and *when*, a major potential impediment to success of the project – the faulty middle management – could be bypassed. Thus the shop planners were brought into the "skunk works." Every single operation in manufacture of the ship's hulls and sphere was identified on process flow sheets and planned in detail using out-and-out production-line planning techniques. The LNG hull and spherical containment design achieved the goal we had set for simplicity, producibility, standardization, and built-in quality to a remarkable degree.

This also applied to other aspects of the ship design and specifications for purchased or subcontracted components, and it happened in large part before regulatory body and customer approvals were obtained on the plans and specifications.

A contract with Burmah Oil for the ships had been signed in September 1972, and as of the end of December the "concurrent engineering" of the ship was a "fait accompli." The engineering contract plans specifications, and purchase and subcontract specifications purchase requisitions had been completed. All owner and regulatory body approvals had been obtained. Bids on all components, subcontracts, materials and other equipment had been obtained and evaluated. Some subcontracts and purchase orders for long lead items had been placed. Production processes, tooling and new manufacturing equipment had been finalized and was on order or on hand. The new panel line was installed and being tested. Purchase specification bids had been obtained, and orders for all materials and subcontracts were ready to place except for sphere insulation which, being highly developmental, required further engineering analysis. It was Veliotis' alleged kickback provision on this contract which was to eventually force his retreat to Greece as a fugitive from U.S. justice.

Management-Imposed Insults to and Other Tests of Product Integrity

While the intrinsic integrity and quality of the Quincy LNG ships has been well proven in subsequent years, the built-in Quality stemming from the concurrent engineering effort also proved almost completely resistant to top management-imposed "insults" thereto.

The first of the management-imposed "insults" to the ships' integrity began on January 3, 1973, the very day that Veliotis took office as general manager. he completely eliminated the Quincy QA function and its budget for those ships of more than

$1 million Fired on that day was the force of twenty welding engineers which were to have moved en masse into the sphere subcontractors plant. Destroyed – as has lately been revealed – were the procedures for manufacturing them which had been painstakingly developed on the basis of the production-engineered and laboratory-prepared welded joints over the prior two years under Bob Eddy. Also destroyed were the process flow sheets for hull manufacture! The plans survived, however, and later, after years of machinations and delays with respect to sphere construction, when the ships were delivered and put in operation, the intrinsic elegance and integrity of the LNG containment system and sphere design was finally demonstrated. On the rest of the ship, the quality had also been assured by the concurrent engineering process!

There is always an exception that proves the rule. This had to do with the tail shafts for the Quincy LNG ships. The day that Veliotis cancelled out all QA measures, the final purchase specification therefor was moving across the desk of Veliotis' hand-picked "chief engineer," who scratched out the requirement for ultrasonic testing. A defect in one of the shaft forgings, identified by the manufacturer, but unreported to General Dynamics absent any requirement therefor, subsequently failed at sea Substantial losses were incurred by the ship owner, Burmah. General Dynamics' resistance to settlement of the resultant Burmah claim collapsed when it was clearly established that General Dynamics' practice prior to Veliotis even on commercial ships had been to require ultrasonic testing on shaft forgings, and the last minute "deletion" of the ultrasonic test requirement was uncovered by the legal process of discovery

The double-bottom feature of the ship proved its worth in 1981 when the fully loaded LNG TAURUS went hard aground on rocks off Tokyo, wiping out 40 percent of its bottom plating The impact was so severe that the U.S. captain committed suicide when he knew the salvage party was ascending the gangway. By virtue of watertight flats partway up the wing walls of the double hull, it was possible to pump air into the lower portions of them, refloat the ship, and take her to the terminal for discharge of the cargo, after which she proceeded to the repair yard under her own steam. The inner hull and support structure(s) for the spheres were not breached nor was their structure damaged Independent experts compare the sturdiness of the Quincy LNG ships to that of a battleship.

Pricing and Marketing the Quincy LNGs

The Venezuela Deal

By virtue of the comprehensive cost engineering effort introduced into the design of both ship and spheres, early in the program we were able to develop a firm price of $69 million per ship. This price required no construction differential subsidy to make it competitive worldwide, and would have produced a handsome profit for General Dynamics. In the meantime, systematic market research by Phil Ross had identified potential clients for the ships. Preliminary purchase and sale agreements were soon drawn up for seven ships to carry LNG from Venezuela to the U.S.; four for the government of Venezuela, and three for a U.S.-flag shipping company headed by Henry Dowd. The gas was to be sold by the government of Venezuela directly to the Philadelphia gas works Helen Bentley, Chairman of the U.S Maritime Commission, was designated by the White House to supervise and expedite the necessary intergovernmental arrangements. The Venezuelan Minister of Mines and Hydrocarbons and of Finance came to Washington one day expecting to finalize them. Maurice Stans, then Secretary of Commerce, gave a luncheon presumably in their honor. Place cards told us where to sit. Present were the presidents or executive vice presidents of seven U.S corporations doing business in Venezuela, a Deputy Secretary of State, several other State Department officials, and myself. Surprisingly, Henry Dowd and Helen Bentley were not there. At lunch we were all asked in turn to stand up and state our business in Venezuela. When I sat down, the man on my left said, "Not one gallon of Venezuelan LNG will ever come into this country." He was Emilio G Collado, Executive Vice President of Standard Oil Co. of New Jersey (Exxon), President of Creole Oil Company, an Exxon subsidiary, and a former Assistant Secretary of State. Stans welcomed the Venezuelans, and then stated, "Not one gallon of Venezuelan LNG will ever come into the United States unless an accommodation is made with Creole Oil." The meeting was over. Leaving the speechless Venezuelans on the podium, Stans came down therefrom, threw his arm around my shoulder and said, "I sure hope you can make an accommodation with Creole Oil!" No Venezuelan LNG has come into the U.S to this date.

Such are the hazards of international ship sales where governments and powerful business interests are involved.

The Maritime Fruit Deal

Our backlog of work to be completed in the yard was rapidly dwindling. We needed to move fast to save the day. Phil Ross came up with the high-flying Maritime Fruit Company, headed by Messieurs Meridor and Brenner But they wanted six oil tankers So we married our engine room design to an available tanker body design to create a quite satisfactory 225,000 DWT oil tanker. It was to be a leveraged lease purchase, but did require MARAD subsidy. We arranged the former with the First National Bank of Boston, and then, with corporate participation, we went to Haifa, Israel, and signed a purchase and sale agreement When I asked what specifications they had in mind other than cargo deadweight and speed, Meridor said, "Lloyd, I know you'll build us the finest possible ship You work out the other design criteria." We adjourned back across the Atlantic and to the board room of the First National Bank of Boston to sign the necessary documents Meridor and Brenner had put up their other ships with the bank as collateral. Andrew Gibson, Maritime Administrator, was there along with General Dynamics President Hilliard Paige. The documents were all laid out ready for signature. Paige announced, "We are not going to go through with the deal." Silence reigned. Meridor asked, "Is the yard for sale?" Paige said yes. Gibson said, "Bergeson, you poor bastard." The meeting adjourned. Meridor, Brenner, and Gibson, contract, financing, and subsidy agreements in hand, flew to New York to see Walt Williams of Bethlehem. A contract was signed for six somewhat larger ships for somewhat more money. The ships were built. Bethlehem got its money. The bank made a fortune. Maritime Fruit went bankrupt in an ensuing shipping slump.

I do not know the moral of this episode. I am still speechless.

The oil tanker design exercise did have one benefit, for we were able to use Dick Myer's revolutionary design concepts. The mid-ship section design was accepted by ABS with minimum comment and paved the way for their prompt approval of the LNG hull designs.

The Burmah Oil Deal

With two strikes against us, Phil Ross produced the Burmah Oil Company. They did want LNG carriers. The ship price, in the meantime, had risen to $80 million per ship. This was by virtue of contracting out the spheres, other legitimate changes in

scope, and corporate pricing manipulations. A contract was signed in the fall of 1972 for three ships and options for seven more. On January 3, Taki Veliotis was installed as general manager of Quincy, and the writer became a corporate vice president without portfolio. The ships were all finally delivered–years later than planned. Despite the delays and kickbacks, David Lewis publicly cited the contract as the most profitable one that General Dynamics had ever had

Shipbuilding Management Systems and Methods

Development of a Fully Integrated Management System at Electric Boat

The dawn of the nuclear age created the opportunity, necessity, and challenge of developing the state of the art of shipbuilding management to higher levels than had ever before been achieved.

In 1950, CAPT H. G. Rickover and others had sold the Navy on the idea of developing nuclear submarines, and putting the concept into effect was considered urgent. Rickover had already strategically established himself as wearing two hats: one as head of the Naval Reactor Branch of the AEC and the other as head of code 08 or a preceding designation in the Navy's Bureau of Ships under RAdm Homer Wallin.

The Navy's plan was to build land-based power plant prototypes based on two different reactors, a Westinghouse-designed pressurized water reactor (STR) and a General Electric-designed sodium-cooled reactor (SIR), and follow them closely with seagoing prototypes which would become SSN 571, USS NAUTILUS, and SSN 575, USS SEAWOLF.

Rickover approached the Portsmouth Naval Shipyard, expecting to enlist their enthusiastic collaboration in designing and building the prototypes, both land and seagoing. Rebuffed by RAdm Ralph C. McShane, then commander of the shipyard, Rickover turned to O. P. Robinson, the man who had led the Groton, Connecticut, yard of Electric Boat Company through the war, and who was soon to retire. He had recently been joined by RAdm A. R. (Andy) McKee, USN (Ret.) who was the undisputed dean of submarine design in the U.S. Electric Boat was down to less than 100 people in design and 700 in the yard. This included a cadre of very skilled submarine design personnel and yard supervisors, but less than 5 graduate naval architects and engineers of any kind. Robinson and McKee were as enthusiastic as ADM McShane had been unenthusiastic. The services of Carleton Shugg as General Manager-Designated were very shortly obtained. Shugg, an Annapolis classmate of Rickover, had enjoyed a short but brilliant career as a naval contractor at Portsmouth before becoming a cofounder of Sprague Electric Company in the late 1920s. He returned to shipbuilding a year before Pearl Harbor as production manager at the revived Cramp Yard in Philadelphia. For the latter part of the war, he headed up the Todd shipyards in the Port of New York, and then shortly after the civilian Atomic Energy Commission replaced the Army Corp of Engineers in charge of all government nuclear installations, he became Deputy General Manager of the AEC.

Shugg soon discovered that schedule commitments on work in hand at Electric Boat were not being met. Both Shugg and McKee were quite familiar with my WWII work at Cramps, and Shugg had later persuaded me to undertake the reorganization of the AEC's large expansion of the R&D and plutonium-producing reactor and associated facilities at Hanford, Washington. I was literally drafted (or snatched) out of General Electric's aircraft gas turbine division, where I was happily teaching their project managers how to plan and meet their commitments to provide even more advanced jet engines and improved reliability for use in the Korean conflict.

When I arrived at Groton to serve as planning manager in May 1951, I found that in addition to my being but the eighth graduate engineer of any kind on the premises, a total vacuum existed in the planning area. I managed to fill that vacuum with a state-of-the-art Group System, which, it was obvious, had the potential for further automation when mainframe computers would come into the market to replace tabulating equipment. To run the system I hired men who had worked with me in the war and the best graduates that MIT, Webb, and other engineering institutions could provide, and proselytized talent from other shipyards; easy to do in view of the postwar shipbuilding slump and the challenge of the project.

The vacuum proved to be a saving grace, for as we moved to create networks, integrate schedules of requirements against all departments, check the plans for producibility, prepare manufacturing B/Ms and installation groups, dispatch the shop work in proper sequence, and relentlessly follow up and eliminate pending delinquencies, we met with no solid resistance from entrenched interests. With notable exceptions, none existed!

The STR prototype had the highest priority as far as getting things on the rails. It was completely stalled out. A task force was set up in a vacant South Yard building headed by one of my MIT-trained, former Cramp planners, Hewitt Townsend. His assignment was to check the body of the plans against the bills of materials thereon, get Design to correct the numerous errors and discrepancies and recheck them until they could be released for manufacturing (as many cycles as necessary!), allocate the material to one or another of the already scoped groups, double check everything in the full-scale mock up, carefully determine the required installation sequence in the very cramped (high packing fraction!) reactor and engine room spaces, write the group lists, and then collect all of the group material (much of it stainless steel pipe, valves, and assemblies). He then had it all given a final inspection, packed it in a crate with the group list as a packing list, and shipped it to the site at Arco, Idaho.

The site superintendent was a boisterous, red-headed Irishman named Joe Milligan. Joe had strong but wrong convictions. He soon caused all work to grind to a halt (again!) by the simple expedient of opening all the crates and dumping their contents in a glorious large pile in the middle of the desert! I sent out my deputy, Myles Clegg (recruited from GE), accompanied by a planner who was to stay on the job. They reassembled the material by group and then, using the schedule based on a rigorous networking, the material was dispatched to the trades in the required sequence. Eureka, the plant went together like clockwork. Lo and behold, Joe Milligan, on his visits back to Groton, began asking his chums in the yard why they did not do things the easy way and use the Group System! Thus, essentially, the system was in its manifold attributes installed on the basis of popular, grass-roots demand generated by its erstwhile staunchest opponent! There was, of course, some resistance on the part of entrenched yard politicians.

There was much, much more to making the Group System work, including overcoming the countervailing pressures and intrigue created by Rickover. He, of course, had his resident representative – independent of the local Supervisor of Shipbuilding. We soon had up to six Rickover projects being engineered, designed, and built concurrently. Several Electric Boat project managers were hand-picked former employees of

his in the Electrical Desk of the Bureau of Ships. All were required to report directly to him or his on-site representative, often bypassing the general manager. All were charged by him with dictating the schedules to be followed in performing his own particular project. Since none of them were planning or managerially oriented, it was necessary to do their work for them, but convince them that it served their individual interests. This was difficult and often frustrating, but not impossible. After all, the total workloads had to be balanced and disciplined in terms of schedules which were fully integrated between projects, or all would have ground to a halt. But it did not. It was, with a slight dash of Machiavellianism, made to work like a charm.

The operation of the Electric Boat system had by 1957 reached the degree of smooth operation which could and did take the POLARIS program in stride simultaneously with a Rickover pet project, the British DREADNOUGHT program, and without affecting delivery dates on the substantial existing backlog. The basic elements of it have been discussed elsewhere [17], and referred to in other parts of this paper. They are briefly summarized below. There was no Electric Boat project manager on either project. We preferred to have none. The planning system provided the necessary coordination!

Attributes of EB Management System Circa 1957–1962

- Ten-year business plan and milestones required to meet it.
- Company-funded submarine R&D ($1–2 million/year) focused on developing attributes of submarine and submarine hardware projected 10 years into the future.
- Master construction schedules created on ***day 1***.
- Comprehensive networking to determine prerequisites to and dependencies on each defined activity or task in the chain from diagrams through test and trials.
- Integrated schedules for all activities pertaining to each ship project, from engineering's decision through ship and weapons test programs and delivery (and, on FBMs, post-delivery grooming). Subnets where appropriate.
- Schedules of requirements against each participating activity, including EB subcontractors, R&D labs, the Navy's GFE subcontractors, as well as the shipyard design, manufacturing, procurement, construction, and test activities.
- Overall master plan and schedule, and work breakdown structure, from day one of contract, based on working back from required delivery date to required actions. Constantly expanded within overall framework as drawing and specifications produced.
- Periodic progress meetings for each project covering all phases of activity. Agenda items – anticipated or actual delinquencies, if any, activity by activity (management by exception). Supervisors of ships and ship's officer attended.
- All material on group lists precollected eight weeks in advance of first scheduled use. Daily 5:00 PM meetings of all concerned to solve the problems involved. Goal (attained!): ***no*** delinquencies when yard scheduled to erect or install.
- Systemized specifications for *all* purchased materials – all categories, precollected as above.
- Stock materials allocated by contract based on planned requirements
- Stock inventory turnover rate – 4 times per year
- Each step in manufacturing and preinstallation processing preplanned, "dispatched" each step strictly in sequence according to schedules of requirements.
- In-process inspections and sign-off required for all steps in the manufacturing process before person or tradesman released to start the next job in sequence. Installation within compartments and tests subjected to similar QA checks and sign-offs.
- Essential paperwork made manageable by use of IBM computer (360–1400 series).
  - — Group and B/M masters
  - — Workload, forecasts, and variance analyses
  - — Material resource and control functions
  - — Group reporting
  - — Schedule variances by task, manhour return and variances
  - — Accounting work-in-process records (tied to labor load forecasts)
  - — Machine shop travellers and dispatch records
  - — Exception reports
- Process planning decentralized to shops and design departments.
- No plans released for manufacture or installation work until planning had allocated all materials in the body of the plan to one or another group or manufacturing B/M, had checked it for producibility and discrepancies had been elimininated. Recycled as many times as required.
- All activities budgeted, returned man-hours collected, variances analyzed on an ongoing basis with remedial steps identified for action as appropriate.
- Change orders, design changes, and field changes engineered and executed on a current basis with priority for actions dictated by schedule requirements.
- Man-load forecasts for all projects by department or trade integrated with schedules of requirements by project and used to project hiring and/or layoff. Variance from forecast periodically analyzed, remedial actions identified and prosecuted on a current basis.
- Appropriate allowance for design changes, rework, and other safety factors (transit time for equipment) provided for in schedules.
- Work priority throughout yard based strictly on schedules of requirements to meet ship completion dates.
- Scheduled ship completion dates were ***never*** changed, even if the projected ship completion date(s) appeared impossible. If variances occurred between scheduled and actual progress on any project for any reason, such as lack of manpower to favor an earlier scheduled ship, it was dealt with as discussed below.

A key prerequisite to achieving a fully integrated management system was a modestly sized loose-leaf notebook titled "Electric Boat Account System"; a development of the earlier WWII Cramp account system, it was meticulously engineered and adapted for the nuclear age under the direction of Alfred M.

Zein. So important to our plans was this document that we gave a course of study in its use to all supervisors from leading man to general manager. At the end of the course they were given an exam. If they flunked, they were required to repeat it until they could pass. Each was then given a book and expected to use it when assigning account numbers or making charges for work performed.

Initially, and with no usable historical cost data, we arbitrarily distributed the "guestimated" man-hours to the accounts, and within the accounts to the tasks or groups (engineering, design, manufacturing, installation, tests and trials) starting with NAUTILUS. As total returned costs on specific completed tasks were reported they were analyzed in depth, and adjustments were made in the estimates or budgets for similar tasks on subsequent contracts. Well before the POLARIS program came along, and despite the increasingly complex systems and substantial differences in scope, between prototypes we were by "difference analysis" able to prepare work unit-based cost estimates and working budgets practically overnight.

Note: A landmark paper presented at the 1976 annual meeting of the Society by Daniel M. Mack-Forlist and Richard A. Goldbach brilliantly presents the case for integrating cost estimating and cost engineering with the planning, engineering, and material and production control processes, and an orderly blueprint for achieving the same. It reflects many of the lessons learned at Electric Boat and Sparrows Point in the 1950s and 1960s [15].

With the system in place 30,000–50,000 activities *prerequisite* to construction, installation, and system tests per ship could be and were monitored every two weeks. The contract span times averaged 33 months. There were at least five prototype and follow-up ships in production at all times. Thus, on the prototypes, 1,200 actions came due per ship (6,000 total) every two weeks for these prerequisite activities. Because of the schedule and budget discipline instilled by the system, the delinquencies and variances to be dealt with per ship amount to no more than 5 percent, or 60 agenda items to be reviewed for each ship at each biweekly progress meeting – often many less. This made "management by exception" eminently practical. The problems or potential problems identified could be and were dealt with before they infected the ship construction progress itself.

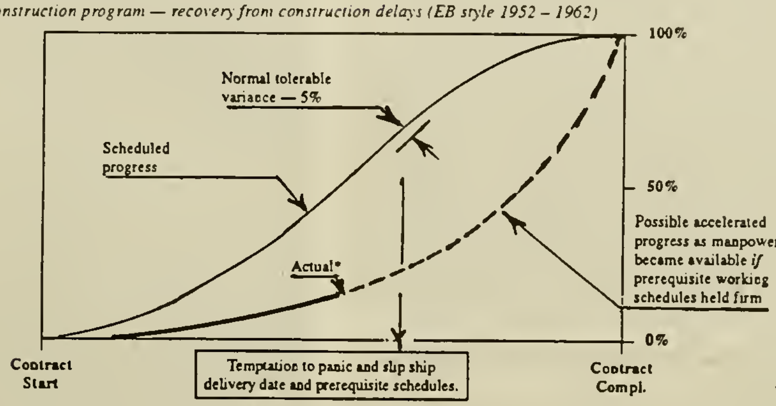
Schedules have an inherent flexibility. All is not on a critical path. *Therefore*, apparently hopelessly inadequate progress to schedule can be recovered on a ship if the prerequisites have been maintained on schedule and the end date is not slipped in a weak moment. We followed this policy religiously, despite all pressures to the contrary. (See Figure 12 below.)

Marketing managers take note! It was the reputation that EB had established in the 1950s for performance to schedule that brought the POLARIS program, unsolicited, to our door in December 1957.

When we undertook POLARIS with its brickbat priority and the British DREADNOUGHT project with *no* priority, we had the following submarines underway, three of them prototypes:

- SSN 585 – SKIPJACK (First combatant submarine streamlined for underwater speed)
- 586 – TRITON (Twin P.W. reactors/twin screw)
- 589 – SCORPION (SKIPJACK class)
- 597 – TULLIBEE (Electric drive)

Figure 12. Ship construction program — recovery from construction delays (EB style 1952 – 1962)



*Based on lack of yard manpower during POLARIS build up.

Note: This basic precept was later proven in two cases where the schedule discipline to support tight concurrency of yard effort had collapsed, but where years of delays had allowed yard work prerequisites to backlog. With ship completion dates reset to tight schedules and held firm, and *ad hoc* discipline applied on a one week planning cycle — repair yard style — the following was accomplished:

Ingalls 1967 – 1969: 14 overdue commercial ships of 4 classes and 6 overdue Naval vessels of 3 classes delivered in 24 months and the yard returned to the Navy's qualified products list.

Quincy 1970 – 1972: 9 badly overdue Naval vessels of 3 classes and 3 overdue commercial vessels delivered, clearing the way for the LNG program.

Despite overall progress curves on individual ships as above, they were all maintained to their original scheduled completion dates. The POLARIS had minimal activity delinquencies, and overall progress equaled estimate. In the case of DREADNOUGHT (just for fun) we progressed this zero-priority project with absolutely no activity delinquencies in any phase of work at any time!

There has been no room to discuss the management of the submarine overhaul business in this paper. Systematic management of overhauls has many aspects in common with the shipbuilding process. John L. Randall captured the essence of them in a 1981 paper, "The Uncommon Sense of Outage Management," delivered to the American Nuclear Society [16]. Serious students of shipbuilding/overhaul management should study this excellent distillation of the basic essential elements of managing a successful overhaul or major project of any type.

EB Long-Range Planning and R&D

The genesis of EB's 10-year plan in the year 1957 is of interest. The then-president of General Dynamics set up the Long Range Planning Group and decreed that each division should develop a 10-year plan. Carleton Shugg was alarmed. He wanted no corporate meddling with the divisions' planning. However, since it was a planning function, I was given the responsibility with the instruction that it was to be a collateral duty and done nights and weekends if at all. I assigned it to Jack Randall, who did a superb job. The same format is still in use today! Corporate then decreed that our plan should provide for diversifying 50 percent of our effort out of submarines! Jack and I argued strenuously that EB was about to corner the submarine engineering market. Instead of diversifying out, we should spend several million dollars a year of corporate funds specifically on submarine development. To our surprise, we won. $1.3 million was budgeted for the next year. We set up a steering committee for company-funded R&D, and Herm Sheets's already established R&D department went to work spending the money. In the meantime we had for $1.00 taken a contract with the Navy to explore the parameters of submarine design ten years hence. Naval architect Bob McCandless was instructed to take a number of months off his other duties and survey all of the branches of the Navy establishment from the Pentagon down through BuShips and the ships' operators. His report was deemed so controversial by Shugg that we defaulted on the contract. But we did use it to shape our R&D program over the next few years, and it all paid out in the Navy's funding and adopting several important EB submarine design concepts. Integrated controls was a major area. The propulsion system described 30 years later by Tom Clancy in *The Hunt for Red October* was a project we researched, but it got further in fiction than in fact.

Management Techniques of ADMs Rickover and Raborn

It might be useful to future shipbuilders to compare the management techniques of ADMs Rickover and Raborn. They were as different as night and day.

At the outset, it should be said that both were honorable men whose word was their bond. Both made good on their commitments.

Let it also be known that the challenge of opening a new scientific and engineering frontier and patriotism were the basic motivations of the many throughout the shipbuilding industry who contributed to these programs. We really believed that there was a Russian threat to be faced down by going beyond the state of the art in weaponry and ships. Hundreds, if not thousands, of us contributed every ounce of energy we had, despite all obstacles, and we would have done so no matter who led the efforts.

Rickover was a bona-fide zealot. He accomplished miracles in introducing a nuclear-powered Navy, but there was an element of overkill there, which he acknowledged at the end. The larger goal, his personal ambitions, had driven him too far. At Electric Boat, Carleton Shugg as general manager tried valiantly to shield his staff from the Rickover venom. But it was at great price to himself, mentally, physically, and timewise. We did great things at Electric Boat in the 1950s, but at times doing them was pretty grim. Some, elsewhere, suffered breakdowns, and at least one contractor committed suicide because of Rickover's pressure tactics.

To the contrary, I cannot remember that there was ever a harsh word or unpleasantry at any time by ADM Raborn, or any member of his staff. Raborn exuded confidence and zest for doing the impossible. His meetings, purposeful as they were, were a delight. There were no discernible cliques or hidden agendas. The facts were always on the table top. We went away refreshed and inspired. The GEORGE WASHINGTON was completed on budget, and to the most "impossible" schedule which had ever been set down for a completely integrated weapons system of any kind – not to mention its being encapsulated in a ship to be operational under water. The same applied to subsequent FBM prototypes. Of course the Rickover prototypes had also been delivered to record-setting schedules which broke new ground. But the Raborn effort involved far less wear and tear on the participants.

Kicking Off the POLARIS Program

The design and construction of the USS GEORGE WASHINGTON and the use of its "schedule of requirements" in coordinating the development of the POLARIS system as a whole was kicked off in the following manner. On Friday, December 30, 1957, RAdm Mumma, Chief of the Bureau of Ships, summoned Electric Boat officials to a meeting in Washington. Present were ADM Mumma, RAdm Red Raborn, head of the Navy's Special Projects Office, RAdm Armand Morgan, head of BuShip Design Division, CAPT Harry Jackson of Code 525, and no doubt others. Representing Electric Boat were Carleton Shugg, General Manager, A I McKee, Electric Boat's Vice President of Engineering, and the writer (in charge of planning). The general concept of the ship and its previous system were disclosed. It was stated that the Navy wanted delivery of the ship in 24 months and that it was to be ready to fire missiles "in anger" in 30 months. They would assign the program the highest priority – "Brick Bat." The submergence depth was to be doubled! When asked to confirm that we could double the depth, McKee and Morgan thought it would be technically feasible. The writer raised the question of the lead time that would be required to design, manufacture, test, and qualify new sea valves and connections for doubled submergence. After due consideration, it was deemed impractical to do that and maintain the schedule. It was at this point that the idea of using the bow and stern of the partially constructed SCORPION was introduced. We were asked to design the hull and sea connections of the added midbody for the deeper submergence pressures – "just for practice."

Over the previous seven years, the Navy had gained considerable confidence in Electric Boat's ability to develop, design and construct a series of nuclear prototypes, both land-based and seagoing, to short schedules – using our integrated planning,

material. production and cost control system. This confidence was demonstrated at the meeting, when ADM Raborn delegated to the writer complete authority over the schedule(s) of requirements against all of the POLARIS contractors in support of the Electric Boat design and construction schedule.

The "contract" was put into gear by a handshake at the conclusion of the meeting.

By the time the meeting broke up, a severe blizzard had descended in Washington and all parties to the meeting departed in haste at 5.00 PM; that is, except the writer. With my "planning hat" on, I needed some design characteristics and parameters of the missile to be built by Lockheed, the launching system to be built by Westinghouse, the fire control system to be developed by General Electric, and the navigation system entrusted to Sperry. I went over to the submarine desk, Code 515. It was deserted save for LCdr Pat Hannifin, later VAdm Hannifin "Pat," I said, "where are the specifications for these exotic POLARIS systems?" "There aren't any," said Pat, "for they exist in concept only." "There's got to be something," said I, "or we can't start the job." "Well," said Pat, "I happen to be reading the only piece of paper on the navigation system." It was one paragraph and a short one at that. I said, "Let's go over to ADM Raborn's Special Projects Office and see what they have." It was 6:30 PM by the time we got there. One lone officer, CDR Verne Killonan, was about to close the last "safe." He produced the equivalent one-paragraph scope sheets for the other systems. I took the next train back to Groton, telephoning my planning staff to meet me at the yard on arrival. I warned them that we would be working all weekend around the clock, which we did. First, we hypothesized the design of the new submarine, and then we scheduled it working back from a required delivery date of December 30, 1959. In scheduling it, we networked all of the principal activities involved in construction and its prerequisite right back to key engineering and top management decisions. By all logic and reasonable span times for such activities, these decisions should have been made and the project started years earlier. But the critical items stood out.

I had introduced this networking principle at Electric Boat in 1951. At that time we called it "dependent sequence analysis," which its anonymous inventor at Newport News had dubbed it in 1928 or earlier in order "to" ensure that keel drawings would come out before those of the stacks!" It had worked like a charm at Newport News. I had refined this technique at Cramps in WWII, and later in the process of teaching General Electric engineering managers how to meet their commitments on the jet new engine developments and performance guarantees. We had been using it across the board at Electric Boat since 1951, and we used it now with a "broad brush." By the time on January 3rd that I was ready to take an early morning plane to NY and thence to Washington, we had, not surprisingly, confirmed the most critical paths to be the fire control system, the missile itself, missile launching system and the inertial navigation system – and in that order.

At 9.00 A.M. I met with ADM Raborn's technical director, CAPT "Red" Smith and his staff, including CAPTs Deke Ela and Munroe Hart. I asked "Where is the Fire Control Systems Diagram?" There was silence. Then – "We don't have one." "Surely you have a functional block diagram," said I. "No, we don't," I was told. "Without it now," I said, "you will not get your ship in 24 months." I was asked to leave the room. After walking up and down for an hour and in high dudgeon, I tried an adjacent door. There was a "functional block diagram" being created on the blackboard. I sent a copy of this back to Electric Boat and with Andy McKee and a Raborn deputy to vouch for us, I boarded a plane for San Francisco. The next morning in Sunnyvale, California, we met with the top engineering and management officials of Lockheed and Westinghouse. "What is the diameter of the Missile?" I asked. "We won't decide that for a year," said Lockheed. "I have news for you," said I. "You will decide the diameter of the missile this morning, Westinghouse will decide the diameter of their launching tube and we, Electric Boat, will decide the diameter of the pressure tube." We did. The dimensions decided on included allowance for retrofitting the larger-diameter POSEIDEN missiles which would come later. Within the week, this performance had been repeated with respect to critical-path items at General Electric and Westinghouse and Sperry.

The rest is history. The GEORGE WASHINGTON was delivered on December 30, 1959, 24 months to the day after we undertook the project. Its weapons systems were ready to fire missiles in anger six months later.

Experts, of course, considered the POLARIS missile system to have been several orders of magnitude more complex than anything hitherto attempted aboard ship – the nearest thing to it having been the marriage of the Regulus missile with a submarine. The Regulus project had not at that point achieved operability even after seven years of intensive effort, nor did it ever.

I have often wondered what would have been the fate of the POLARIS program if we had caved in to the demand for doubled submergence depth on December 30, 1957.

The Genesis of PERT

Prior to joining Electric Boat in May 1951, I spent a year at General Electric's Gas Turbines Division(s) in Lynn, Massachusetts. Jim LaPierre, the General Manager, had asked me if I could teach his project engineers to plan and to meet their commitments. I did this using basically two shipbuilding techniques. The first was to have them set up milestone schedules of principal events based on their own estimates of time between them and then to vigorously progress them. The second was to introduce the idea of defining and networking all of the activities involved in the development process. These networks combined all support work and time estimates to accomplish each task made by those responsible for the engineering R&D. The requirements to set milestones caused the project engineers to think about prerequisite and dependent activities. The networks forced them to think through the whole development and engineering process in disciplined manner. That gave them the ability to manage their programs objectively and gave General Manager LaPierre the tools to use in ensuring that they did so and were supported throughout the organization and logistically.

Improvement in the Divisions' ability to meet commitments and schedules was so dramatic that I was asked to set up an "Operations Analysis" function, and to develop a network-based five-year business development plan (the first five-year plan in GE's corporate history) and a supporting 12-month operational plan. GE's President Cordiner made this system of business and engineering planning and control mandatory throughout GE. When in 1957 ADM Raborn was looking for a management system to use for the POLARIS program, he consulted his brother, who was a GE executive. The brother recommended using the GE "standard practice" which I had developed in 1950. With (questionable!) probabilities added to the networking by Professor Livingston at MIT, this became the "Program Evaluation and Review Technique" or PERT. ADM Raborn specifically requested that we not spoil the Electric Boat management system by adopting the "political relations" (PR) system network which PERT represented and which was

specifically to ensure congressional and White House support without invoking the usual attendant nit-picking.

DOD Instructions 7000.1 and 7000.2 (1966 and 1967), Performance Measurement for Selected Acquisitions (Superseded by DOD 5000.1 and 5000.2 in 1991)

The dramatic success of the POLARIS Program which brought forth the prototype Fleet Ballistic Missile submarine GEORGE WASHINGTON in 30 months from concept (12/30/57) to readiness to fire missiles in anger (6/30/60), generated great interest and curiosity throughout the Department of Defense, government contractors, industry in general, and the public. How could so much have been accomplished on such a complex project in so short a time? NAVSEA's interest had already been stimulated by an audit of the management systems in use both in private shipyards and naval shipyards. This audit was headed by RAdm Jimmy Farrin. They found the Electric Boat management system and practice to be superior in every aspect. In 1963 and 1964, symposiums on program and project management were held for the defense and aerospace industry, jointly sponsored by the Navy's Special Projects Office and the American Management Association. The writer was called upon to describe the philosophy, systems, and procedures used at Electric Boat. The logic of developing and the benefit to be derived by developing and using from day one an integrated network of all tasks, fully budgeted, for all elements of the project within a comprehensive chart of accounts, and then managing the progress of the work in terms of those tasks on the principle of "management by exception," had been clearly proven on the GEORGE WASHINGTON and its revolutionary weapons and navigation systems.

Apparently, I explained the philosophy and principles of Electric Boat's management system well enough. Within months thereafter, the Navy was requiring proposals on development projects to include such networks, and in 1966, DOD instruction 7000.1 was issued. 7000.2 followed in 1967 [22]. These promulgated auditable criteria that successful shipyard management systems must embrace for a complex program to be successfully carried out, regardless of the sponsorship. Yards which have really put the fundamental principle to work in parallel with compliance with the spirit of Q A Mil Specs Q9858A and 145203A have found that it is easier, much more fun, and far more profitable to follow these fundamental principles, the industry equivalent of $F = \frac{W}{g}a$ and $E = MC^2$, than to manage less rigorously or worse.

DOD instruction 7000.2 is a prime example of an absolutely necessary government "regulation" at its very best, for it goes far to ensure that fundamental shipbuilding management practices are maintained without dictating specific practices. In 1991, 7000.2 was superseded by 5000.2 [23].

Shipyards whose management systems are currently validated under 5000.2 are:

Electric Boat–SEAWOLF Program
Newport News–Carrier Program
Bath–AEGIS
Litton–AEGIS
Avondale–LSD Program

NASSCO is in the process of being revalidated

Cost/Schedule Control System Criteria Implementation Guide (C/SCSC) of October 1, 1987.

In conjunction with DOD Directive 5000.1 and its predecessors, DOD and the Navy also promulgated for the mutual benefit of the contractors and the Navy a "Cost/Schedule Control Systems Criteria Guide" (C/SCSC) of March 1, 1972, and reissued in 1987 [24]. This covers organization, planning, budgeting, accounting analysis, revisions, and access to data. One can recognize within them the same basic principles and management practices which, during the 1950s, we at Electric Boat were refining and putting to use–absent such directives and guidelines–in the development and construction of the Navy's nuclear attack and fleet ballistic missile submarines.

Rational Application of Fundamental Management Principles versus Constructive Claims

7000.2 and C/SCSC in 1967 were the antitheses of the "principles" (or, more correctly, lack of them) behind the constructive change feeding frenzy which commenced at about the same time and reached epidemic proportions in 1977, when unsettled claims peaked at $2.7 billion. The Navy's early attempts to invoke them lacked the necessary muscle. Thus, early applications were not applied in the yards with enthusiasm or effectiveness, even as the planning abilities and controls that they had had to begin with eroded as a function of the massive claims efforts combined with lack of practice in true planning that comes with prolonged series production of the same product. At Electric Boat, 7000.2 and C/SCSC were first used on the design phase of the TRIDENT program, the first ship of which was SSBN 726, OHIO.

Had these guidelines (7000.1 and C/SCSC) been available to and enthusiastically accepted by naval combatant ship contractors a decade earlier than they were (1957 instead of 1967), and if they had resolutely implemented them, I doubt that the shipbuilding industry's management systems and controls would have self-destructed to the degree that they did starting at the same time [1967] as a function of the constructive claim phenomenon; nor would the Navy's procurement organization, including NAVSEA, have been so enormously damaged.

It is ironic that these fundamental management principles are finally being systematically effected even as the Navy's shipbuilding program is being subjected to the probability of severe post-Cold War shrinkage.

Other Management Use of Networking and Interactive Computer Models

Ship Owner's Defense Against a Shipbuilder's Constructive Claim

In 1976, FMC Corporation submitted to arbitration a constructive claim in the amount of $100 million to cover cost overruns incurred in the design and construction of six 33,000 DWT (double-hulled) gas turbine tankers for the account of Chevron Shipping Company of San Francisco, California. The fixed price contract was for approximately $16 million per ship, to which $6 million in contract changes had been added, bringing the authorized total per ship to $22 million. One ship was never built, nor were costs incurred on it. Therefore, the average overrun for each of the 5 ships built was $20 million – all of which was claimed. FMC had undertaken to build these ships

in the Portland, Oregon, yard, previously devoted to railroad car and barge construction. The yard had a good record in those fields, but no personnel anywhere in the yard who had ever had responsibility for any phase of design or construction. The design was subcontracted to the Seattle firm of Nickum & Spaulding No person or persons with prior shipbuilding experience were introduced into the yard until four years into the contract, nor had any attempt been made to examine the documented state of the art.

The writer was engaged to analyze the situation for Chevron and help engineer a defense against the claim. As a base line for measurement of analysis of the FMC claim, I produced a "Shipbuilding Management Model" [17]. This described state-of-the-art practice as it could have been applied in a start-up situation to the design construction of such purposely simple ships. It assumed a basically competent management augmented by a few competent shipbuilders in key positions. The yard's performance (or lack thereof) was then analyzed in terms of the written model and equated to the resultant delays and overruns. It was obvious that every precept of state-of-the-art shipbuilding management had been breached.

In the course of the analysis it became obvious that the ships had been priced below the best cost that would have been obtained in a start-up yard with professional shipbuilding management added ($24 million), corrected for changes.

To back up the expert opinions of myself and others, it was deemed prudent to formally network the entire scope of the shipbuilder's design and construction responsibility, working from contract plans and specifications and change orders as provided to the shipyard and its design agent, and then to exercise it using a state-of-the-art critical-path method scheduling package with a resource allocation and smoothing capability. (Project 2 software was selected.) The required precedence diagrams and other inputs were developed by experienced ship construction planners and estimators under the leadership of long-time shipbuilding colleages, naval architect A. P. Bates and Frank McConnell All phases of the FMC activity were included, along with 100 milestones (added later) and basic restraints such as launching. When operational, it confirmed in spades our prior expert conclusions. However, the shipowner's factual testimony and a modicum of expert testimony was all that was required to settle the case. The computer modeling was not required. The arbitration award was but $3.5 million per ship, or $17.5 million, as opposed to the $100 million claimed. In addition, FMC had to swallow the $20 million they invested in preparing their claim.

I personally had been pleasantly surprised at the relative ease with which we built this model [1977], and it convinced me that such a model, properly used, could be of immense advantage in planning and executing shipbuilding contracts even on first-of-a-kind, simpler ships such as tankers, to say nothing of combatant prototypes. If such has been done in U.S. shipbuilding other than recently on the AEGIS and SEAWOLF projects, it has escaped me.

Simulation Modeling on Ingalls' Constructive Claim

A computer simulation model was used successfully in 1976–78 to help Ingalls resolve a $500 million claim based on the "ripple" effect of several thousand alleged Navy change orders on the 5-ship LHA program and the 30-ship DD963 destroyer program [7]. Both had been contracted as part of the Total Package Procurement Program dreamed up by the Pentagon toward the end of the MacNamara era. The rigorous planning that had been introduced in the East Bank Yard on submarines and surface ships had never completely taken hold on the West Bank for several reasons, including the constructive claim syndrome, which does not thrive in a tautly run shipyard.

Simulation modeling is a derivative of the field of System Dynamics invented at MIT and first brought into prominence by Jay Forrester and his associates. It is now an accepted approach for use in managing and bringing a semblance of control to large, complex projects which have not enjoyed prosecution in accordance with the guidelines incorporated in DOD 7000 2.

It is reported that Ingalls has later been able to use simulation modeling in a more proactive manner in a corporate planning mode.

The 1981 Major Overhaul of the Eight-Reactor Aircraft Carrier ENTERPRISE

The planning and control functions of the Puget Sound Naval Shipyard suffered a nervous breakdown when confronted with the monumental task represented by this overhaul. Then Captain Roger Horne was brought in to get the program back on the rails and particularly predict the firm completion date for the overhaul. He inventoried the status of the ship, rescoped all the work to be done, determined precedences, and then, using a computer and his own brand of simulation modeling, predicted a firm completion date. He then put the working schedule back together in support of that date. Overhaul was completed with flying colors to the predicted date.

It is quite within the realm of possibility that simulation modeling used in a proactive mode can be used in conjunction with other planning and networking techniques, and to advantage in the business of building complex ships [18].

SNAME "Marine Technology," SNAME "Journal of Ship Production" and National Shipbuilding Research Program (NSRP)

The above-listed journals and the ever-increasing bodies of knowledge in accessible data banks did not exist until recently. The latter would scarcely have been manageable even twenty years ago. They are a mighty adjunct to the Society's transactions and section papers. The shipbuilding learning curves of WWII would have substantially decreased if the equivalent body of knowledge had been available and accessible at that time. The valuable national shipbuilding research program should be nurtured and intensified.

Process Advances

Lofting and Burning

One of the most significant changes in shipbuilding technique after World War II was the progression of lofting from full scale to one-tenth scale, and from one-tenth scale to numerical. These lofting changes, in turn, were made possible through the progressive development of burning machines.

I am indebted to Frank McConnell, Planning Manager, Metro Machine Corporation, Norfolk, Virginia, and the late Han Hirschberg, Dr. Ing, Quality Assurance Manager, Messer Griesheim GmbH, Frankfurt, West Germany, for the following concise history thereof [19]:

> At the beginning of the 1950s, multiple torch-burning machines were available in several configurations but were all dependent on full-scale templates of one form or another Full-scale templates restricted the size of pieces to be cut. Although quite efficient for small pieces such as brackets

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and inserts, the manufacture of larger pieces like shell plate by this method tended to be awkward.

The proper combination of servo drives, photoelectric tracer, and one-tenth scale drawings – all fairly recent developments – was combined and introduced in an advanced burning machine in 1953. Curiously, this breakthrough machine – the West German Schichau Monopol – operated from 100:1 ratio glass slides photographically reduced from one-tenth scale drawings. Despite some drawbacks, the machine was successful and included several installations in the United States.

Several years later a second West German development, the optical projection tower, became available. This system projected images from the same type of glass slides used by the Schichau Monopol from a tower atop the fabrication shop to a plate on the shop floor. The outline of the finished ship's plate was then centerpunched in the raw plate and cut out with a hand torch. In addition, other information such as bend lines, frame lines and piece part numbers were incorporated into the glass slides and transferred to the plate.

Together, these two developments made one-tenth scale lofting, with its attendant economies, possible. One-tenth scale lofting could be accomplished with fewer workers in a smaller area with significantly greater accuracy than was possible with full-scale lofting. A further benefit was that the smaller templates made larger plate sizes (and reduced welding) practical. To keep pace, the standard photographic reduction ratio for glass slides soon grew from 100:1 to 143:1 to accommodate the larger plates.

Further developments came in rapid succession. In 1957 a stand-alone one-tenth scale pilot machine for controlling burning machines by photoelectrically tracing either one-tenth scale drawings or one-tenth scale images projected on a ground glass screen from glass slides was introduced by West Germany's Adolph Messer, GmbH. By 1959, these pilot machines could direct burning machine torches along two separate paths (three axes) and control burning head orientation so that bevel cuts along a curved path were possible. At the same time, Messer began development of a numerically controlled burning machine as a joint project with Norway's Central Institute for Industrial Research. The prototype, using a hard-wired numerically controlled director with coded paper tape input, was tested at Stord Shipyard in Norway in 1960.

The Central Institute continued development of a numerical, computer-based lofting program in the early 1960s. This program, now known as Autokon, became the genesis of all numerical lofting programs used today. With numerical lofting, ship design can be accomplished by computer from preliminary design through lines fairing to piece part definition. Almost all shell, bulkhead and deck plates can be described and nested ready to cut with minimum plate waste. With quality equipment, accuracy of parts definition is virtually absolute.

Numerical burning found its way to the United States in the late 1960s and when the Maritime Administration sponsored the distribution of the Autokon program under the National Shipbuilding Research Program, numerical lofting took hold as well.

Development of numerical lofting/burning continues. Special purpose, dedicated computers for numerical control, (CNC) which eliminated intermediate steps such as paper tapes were introduced in 1972. Today, CNC burning machines are available with as many as five continuous path axes, eight point to point axes and four displacement axes (for tasks such as interchange of burning torch and marking tool on the prescribed path). Most vertical cutting in the shipbuilding plate thickness range is now at high speed via the underwater plasma arc process with oxy-fuel used mostly for bevel cutting. And full-scale lofting is virtually extinct.

Vertical Full-Penetration Electrogas Welding

This welding method was developed to the point of commercialization at the Paton Institute of Electric Welding in Kiev, Russia, and was introduced into the United States in 1959. During the '60s, it came into increasing use in bridge construction and for hull butts on commercial ships. In 1968 it was used with great success in the construction of the modularized midbody of the ore carrier STEWART J. CORT at the Litton/Erie facility. Due to quality assurance problems on bridge construction and the decline in U.S. commercial shipbuilding, it enjoyed decreasing numbers of applications in the 1970s and 1980s. Recently, however, it has been qualified for use in the construction of tanker midbodies using extensive modularization and the proprietary curved plate MarC Guardian construction method under development by Metro Machine Corporation of Norfolk, Virginia. It could (and should) also contribute to the lower cost of construction of double-hull tankers of more conventional construction.

Hull Modules and Preoutfitting

We have noted the construction by modules and preoutfitting thereof, particularly submarines, in WWII. Extensive preoutfitting of modules on naval auxiliary ships was also tried at the Quincy yard of General Dynamics in the 1960s. The Ingalls shipyard of the future (circa 1970) was specifically laid out and engineered on the premise that it would be efficacious to build and preoutfit modules on naval surface ships of up to 500 tons. Also, modular construction and preoutfitting thereof undercover is the method of construction at both Newport News and Electric Boat. Preoutfitting is reported to have reached at least 85 percent of its full potential in both yards.

Jack Randall points out the story behind this all-important aspect of the shipbuilding/shipbuilding management achievements at EB. It relates to the ULMS-STRATEX-TRIDENT program, and I quote him.

> The concepts of producibility and maintainability were turned from buzz word objectives in the study phases into real life designs and construction actions. It didn't just happen! People like O.B. Nelson, Jack Spinner, and Ed Lindahl forced the design and production paper to reflect the details that made the planned preoutfitting take place. (The Group System made it possible to schedule and police the actions.) The place of Quonset was a material part of this revolution. From a few percent to 85 percent was indeed a revolution. I doubt that a ship as large and technically complex as the TRIDENT could be built anywhere near a five-year construction period without this change. The TRIDENT program, although all Electric Boat, represents a

major part of the U.S. shipbuilding since its introduction in the 1970s.

In commercial shipbuilding, modularization of deck and pilot houses and complete factory preinstallations therein was attained by the early 1970s, and the approach had been recognized for its cost and schedule advantages.

The modularization trend on submarines has been accompanied by an increase of up to three times in the number of plans involved and in their content. Handling this increase has been facilitated to some degree by the use of 2D to 3D computer programs for arrangements, the layout of systems therein and development of systems details.

Modern Ship Coatings

Epoxy coatings in particular, which began to be specified in the late 1960s were not introduced without trauma. However, when it was finally realized that the metal had to be absolutely clean and the coatings were properly applied under carefully controlled conditions, the results with respect to prevention of corrosion of steel hulls in service was spectacular.

Full-Scale Wood Mock-Ups

On submarines full-scale wooden mock-ups continue to be used at Electric Boat to arrange equipment within compartments or modules, to lay out systems within the compartments, to prepare pipe templates and flow paths for installing machinery and equipment as well as to remove it for servicing. While computer aided design had been used experimentally with success in certain instances of support facility design, the mock-ups and traditional paper and pencil were in 1990, according to James Turner, Electric Boat's president, more accurate, faster and less expensive than CAD for finalizing arrangements within compartments.

At Newport News also, wood mock-ups have until recently continued to be used in the development of machinery and equipment arrangement plans. A company-developed 3D modeling technique, VIVID, is now used for arrangement and detailing of piping, electrical and other systems within compartments or modules.

Computer Aided Design (CAD) and Critical Path Methodology

Three recent and excellent papers illustrate how application of these developments in the state of the art are now being used to advantage in the design and construction of complex ships to advantageously interlink all aspects of ship design and construction methods.

- "Concurrent Engineering: Total Management in Design" [13].
- "The Application of Critical Path Methodology to Management of Ship Design Programs" [20].
- "SEAWOLF Design for Modular Construction" [21].

These efforts, in part inspired by Navy-sponsored programs which have encouraged computer-assisted planning and management in support of basic principles, convince me that the Navy and industry are indeed advancing the state of the art of shipbuilding management and that the wonderful human brains on which we have, in the past, had to rely to fill too many gaps in our management and engineering "tooling" can indeed be more effectively supported across the board in efficiently planning and producing all classes of ships of optimum quality on time and within budget.

Where the cost effectiveness of these computer applications lies apparently remains to be seen.

Finite Element Analysis and Other Advanced Technology Applied to Ship Structures

Following the development of the Quincy LNG tanker spheres using finite element analysis, this design method soon spread. Through its use, designers could and did reduce scantlings, and therefore ship construction costs, to a considerable degree, without impairing the strength of the ship at sea. But the criteria incorporated in Classification Society rules and developed over 10 or so decades of empirical steel ship design development included factors of safety built into the scantlings. What was forgotten was the ability of these ships' conservatively designed hulls to withstand localized impacts such as damage inflicted by contact with piers, bollards, and low-energy groundings. A good example of a ship with overly reduced scantlings was the 33,000 DWT tanker ALVENUS (now CRIMSON KING), which grounded so lightly in the Ship Canal to Lake Charles, Louisiana, in 1984 that the crew was unaware of the impact. The bow was broken off, the main deck crumpled, and 10,000 barrels of oil were spilled!

But that which was taken out of the scantlings by finite element analysis could be put back in – in the right places – using the same technique!

To their great credit, the American Bureau of Shipping has impressively addressed these problems in a positive manner in their ABS RULES 2000 program for the enhancement of ship safety. Their program to date can best be summarized by borrowing from their February 1993 Activity Report [29], as follows.

> The objective of RULES 2000 is to improve ship safety through the use of advanced technology. This is being achieved through the modernization of ABS Rules using state-of-the-art analytical techniques, development of advanced design resources for the marine industry, and technical support services for customers.
>
> Under RULES 2000, ABS has already produced several particularly noteworthy advancements. One, first offered to the public in 1991, is the Dynamic Loading Approach (DLA) – a "design-by-analysis" procedure for more accurate modeling of expected ship loads and dynamic stresses than with traditional methods. DLA allows a more rational distribution of material in the hull structure and results in conservatively biased scantlings.

Note: The Dynamic Loading Approach is already being successfully applied in practice [26].

> A second phase of RULES 2000 has been an ... undertaking parallel to DLA to enhance the applicability of traditional ABS hull-structure requirements through the development of strength criteria for all large commercial vessels based on a first-principles engineering approach. This will allow designers, for the first time, to have access to a thorough quantification of stresses that may exist in a ship's structure. The project's current concentration is on tankers, and will be followed by bulk carriers and other ocean vessel types.
>
> This second phase of RULES 2000 has ... resulted in the release of the *Guide for the Fatigue Strength Assessment of Tankers*.... [T]his guide, with supporting PC-based software,

is [already] benefiting owners and designers in ultimately reducing instances of fatigue-related problems.

Next under this phase of RULES 2000 will be the publication of a strength guide for advanced dynamic design and evaluation of double-hull tanker structures. This revolutionary design tool, accompanied by its dedicated applications software for personal computers, will allow designers to address designs in terms of fatigue, yielding, and buckling demands to be resisted by the hull structure, leading to improved design and enhanced structural safety

Double-Bottomed and Double-Hulled Oil Tankers

Prelude

The double-hull tanker saga began in 1970 when the oil companies were lobbying Congress for legislation to enable development of North Slope oil and its shipment from Valdez. The requirement for double hulls for ships on that run had been in the U.S. House and Senate enabling bills, but was taken out as a function of oil company lobbying.

The IMCO Conference of 1973 (Marpol)

Following the TORREY CANYON disaster in 1967, there was worldwide recognition that drastic measures had to be taken to minimize oceanic oil pollution resulting from accidental groundings and collisions, as well as deliberate discharge of oily ballast at sea. Thus, the main objective of the conference was to achieve by 1975, if possible, but certainly by 1980, "the complete elimination of willful and intentional pollution of the sea by oil and other noxious substances as well as the minimization of accidental spills."

In preparation for the meeting, a comprehensive U.S government/industry study found double hulls and double bottoms were, in that order, the way to go from an environmental point of view. But the cost studies and economic analysis were based on overstated and unsubstantiated estimates, made in Japan, of the construction costs for double-hulled ships. The Japanese shipyard(s) who made the estimates had had no experience in building double-hulled or even double-bottomed ships. No effort was made to check the estimates against those of the Quincy Yard of General Dynamics and of Sun Ship, who had double-hull projects well underway; or of other U.S shipyards with experience in building double-bottomed ships. Nor did the economic analysis include any allowances for the environmental damage from oil spills and discharges [27]. Exxon's fierce corporate opposition to the double-hull tankers over the last two decades is reported to have stemmed from this study in which they were participants!

Also, there was impressive evidence from the studies of 30 actual oil pollution casualties in U.S. waters. This evidence, summarized in a 1973 paper by James C. Card, found that double bottoms alone would have effectively prevented outflow in 27 of the 30 casualties [28]. These findings have never been challenged. Every subsequent grounding of double-hulled ships has confirmed them!

In June 1973 the Coast Guard issued an advanced notice of a proposed rulemaking that would require segregated ballast and double bottoms. The U.S. then proposed adoption of these regulations at the IMCO conference of 1973. The IMCO technical committee rejected it for economic and technical reasons, but recommended segregated ballast tanks for tankers over 70,000 DWT and improvements in "load on top" requirements. The technical reasons against double bottoms had to be specious on the face of them. Double bottoms had been incorporated into commercial ships since the dawn of iron ship construction. All who had built them, including the writer, and certainly many of Exxon's technical staff, knew from experience that they were easier to build, no more costly, and, if properly engineered, could be less costly than their single-hulled ships. In 1974, the then president of NASSCO, C. L. French, testified before Congress that the incremental cost of building a double-hull versus a single-hull tanker was less than 2 percent. Also, double hulls for chemical tankers had long since been mandated, and at least 24 of them have been built in the U.S. since WWII. Forty-six oil tankers with double bottoms were built in the U.S. in the decade from 1980 to 1990. The 26,000 DWT GREAT EASTERN, conceived by Isambard Brunel and launched in 1858, was double hulled. The longitudinal subdivision therein was watertight. Shortly after being put into service, it survived an encounter with the then uncharted rock off the tip of Long Island Sound, which rock still carries its name. An 80-foot gash was ripped longitudinally through one of the watertight bays. The bay's damage was repaired in the water using a cofferdam.

The U.S delegation did not go on record as opposed to the technical committee "recommendation," nor did the U.S. government take unilateral action to invoke the regulations for ship trading to the U.S. Thus, the main objective of the 1973 conference was negated

The Sun Shipbuilding ECOLOGY Class Tankers

In 1970, and in anticipation of the flow of oil from the North Slope via Valdez, Sun Shipbuilding & Dry Dock Co signed a three-year contract of affreightment with Sohio, by then a subsidiary of British Petroleum, to transport oil from Valdez to the U.S markets. Sun's president, Paul Atkinson, felt that for safety's sake and economy of operation, the ship should be double-hulled. The PRINCE WILLIAM SOUND was delivered in 1975, and put in service on the Valdez run in 1977, when the terminal then became operational. Two others followed: the TONSINA in 1978 and the KENAI in 1979. These bank-financed and owned sister ships were put in the Valdez service by SOHIO under time charter, but have since been withdrawn from that service. The ships are reported to have lived up to expectations. Their construction cost was less than 5 percent greater than the cost their single-hulled counterparts.

While LNG tankers with double hulls continued to be built in the U.S. in the 1970s and into the 1980s, no other double-hulled oil tankers have since been built in the U.S.

The Studds/Magnuson Bills/President Carter's Initiative/IMCO 1978

From a regulatory point of view, the subject of double hulls remained dormant until December 15, 1976, when the ARGO MERCHANT ran aground off Nantucket and spilled 23,000 tons of #6 fuel oil. This was followed by the SANSINENA explosion in Los Angeles Harbor on December 17, and then a series of nine serious accidents involving oil spillage in U.S. waters over the next two months. The public, including the writer, was enraged, and demanded congressional action mandating double bottoms, at least. The Studds (House) and Magnuson (Senate) bills resulted. The Magnuson Bill requiring double hulls passed in the Senate. The Studds bill in the House

was compromised to exclude the double hull provision. The compromised bill required double bottoms only

An aroused President Carter in a March 1977 message to Congress (the Presidential Initiatives) included among other measures "Reform of ship construction standards to include double bottoms and segregated ballast on all new tankers over 20,000 DWT tons." In May 1977, the Coast Guard published proposed new regulations incorporating these requirements. Hearings were held and they were made ready to issue

The Presidential Initiatives had also included a call for a special international conference to deal with the problems of oil pollution from tankers (in retrospect a major strategic error!). The meeting apparently could not be scheduled until 1978 By the time the conference was held, "international and domestic" opposition to the double bottom provision had been orchestrated to such a degree by Exxon and the American Petroleum Institute, that the U.S government stood alone on the subject and the delegation headed by the late RAdm Benkert caved in, and did not go on record as opposed (the second time in 5 years!).

The U.S delegation had apparently swallowed the fiction that single-hulled tankers would be as safe as double-hulled tankers on the dangerous Valdez run – *if* extra precautions were taken in navigation Back in the U.S., the Coast Guard quickly and permanently deep-sixed the regulation. Heavily involved with other environmentally oriented efforts, I was not to become aware of this shameful episode for eleven years. The 1978 IMCO Conference results were reported by W. D Snider [25].

The Oil Pollution Act of 1990

When the EXXON VALDEZ hit Bligh Reef in Prince William Sound in March 1989 and dumped 250,000 barrels of oil into it, there was more than a public outcry Responsible journalists such as Matthew Wald of *The New York Times*, quickly uncovered the fiction with respect to single-hulled tankers that Exxon had been promoting since 1972 [30]. In May (awakened like Rip Van Winkle) I pointed out to my Congressman, Gerry Studds, that he should try again – but this time call for double hulls. I cited the grounding of the LNG carrier LNG TAURUS (see page 28) as but one example of double-hull efficacy in high-impact groundings. Bills were soon introduced in the House and Senate.

The House bill called for double hulls to be mandated for new ships immediately, and the phase-in of double bottoms for existing ships over seven years. The Senate version, as a result of hard lobbying by the oil industry (they apparently found it easier to lobby 100 senators as opposed to 435 representatives), called for a year of study by the Department of Transportation before deciding on double bottoms *or* other alternatives, and a wait of 15 years before the entire fleet was upgraded! Then, for over a year, there were hearings galore and intensive lobbying on both sides. On the double-hull side there were arrayed not only environmental groups, but the Shipbuilders Council of America representing the bulk of the remaining U.S. shipyards. I personally decided that in the public interest I would attempt by letter and phone to educate the staff members of the Committees on technical aspects of single- and double-hull tankers, and I did. Excellent investigative reporting in the press (*The Wall Street Journal* being a conspicuous exception) educated the public.

On August 18, the Oil Pollution Act of 1990 had been passed by both houses, and became public law 101-380, signed by President Bush [31]. The important requirement for double hulls for all new construction was in there, but with important modifiers: the phase-out of older, single-hull vessels was extended, and other provisions affecting tanker design were also spelled out.

> (1) OTHER REQUIREMENTS – Not later than 6 months after the date of enactment of this Act, the Secretary shall determine, based on recommendations from the National Academy of Sciences or other qualified organizations, whether other structural and operational tank vessel requirements will provide protection to the marine environment equal to or greater than that provided by double hulls, and shall report to the Congress that determination and recommendations for legislative action
>
> (2) REVIEW AND ASSESSMENT. –The Secretary shall –
>
> (A) periodically review recommendations from the National Academy of Sciences and other qualified organizations on methods for further increasing the environmental and operational safety of tank vessels;
>
> (B) not later than 5 years after the date of enactment of this Act, assess the impact of this section on the safety of the marine environment and the economic viability and operational makeup of the maritime oil transportation industry; and
>
> (C) report the results of the review and assessment to the Congress with recommendations for legislative or other action

The National Research Council Marine Board Committee on Tank Vessel Design

This mandated committee first met on November 6 and 7, 1990 The chairman was Dr Henry S. Marcus of MIT. The vice chairman was William O. Gray of Skaarup Shipping Corporation. Gray, in the 1970s, had been point man for Exxon in opposing double bottoms for tankers.

The committee completed its work on, and a valuable but somewhat ambiguous report was issued on, February 12, 1991 [32]. It stated "that they did not identify any design as superior to double hulls for all accident scenarios." It recommended further research and noted that some members favored the 10T DW DS "mid deck" approach as a possibility worth exploring, and that this should be accomplished under IMO auspices before the Coast Guard took action on OPA-90 (i e., delivering a report to Congress!) as required by the bill.

In the opinion of the writer and of others, the committee underrated the ability of double-hulled tankers to withstand high-energy groundings without rupturing the inner hull, and therefore spilling oil or other cargo – notable examples being two high-energy groundings of LNG tankers and one of a cargo ship with a double hull, and indeed that of the GREAT EASTERN. (See Figure 13, page 41.) There have been several others None have caused rupture of the inner hull.

The IMO Comparative Study of Tanker Designs

The IMO study of tanker designs alternative to double hulls centered on the mid-deck tanker concept of Mitsubishi, Japan. A worldwide program on it was largely funded by Exxon through INTERTANKO, and the Oil Company International Marine Forum. A large, international steering committee included Dr. Henry Marcus and W. O. Gray. Amendments to the regulations of MARPOL 73/78 to include the mid-deck tanker as the equivalent of a double hull were approved by IMO at a meeting in March 1992. RAdm Henn reserved the position of the U.S. delegation on all provisions of the amended regulations, and stated that it would not consider any amended MARPOL provisions which are inconsistent with the Oil Pollution Act of 1990. (Hurrah, at last!) Further – after extensive probabilistic analysis of double-hull, mid-deck and other tanker

design configurations done by Herbert Engineering under the sponsorship of the Coast Guard. ADM Kime, the Coast Guard Commandant, issued the long-awaited report to Congress in January 1993. The report comes down emphatically in favor of double hulls. It is disappointing, however, from a safety view, that neither the Coast Guard nor IMO regulations for double hulls increases the required double-bottom and double-side width with the size of the vessel. Most independent experts would recommend $B/15$ or 2 meters, whichever is greater! It certainly would be sensible.

The High Price of Oil Industry and Government Irresponsibility

Implementation of the objectives of IMCO 1973 was set back 19 years by the above-described shenanigans which resulted in failure by both government and industry as a whole to take obvious, reasonable, responsible, and timely actions to provide double-bottom and/or double-hull tankers as soon as it became obvious that they could importantly limit oil spills from collisions and groundings. The principal result has been immense and accelerating damage to the world's environmental and ecological viability – which could have been avoided. A secondary result was the complete collapse of the commercial shipbuilding industry in the United States in 1988.

Worldwide Double Hull Construction

The first owner to commit to double-hulled tankers following the EXXON VALDEZ disaster was the Conoco Oil Division of duPont, who ordered two 95,000 double-hulled ships to be built in Korea. They did this prior to OPA 1990.

Worldwide, the mounting list of double-hulled ships is beginning to be impressive. Under ABS class alone there are 38, 14 of them completed in 1992, and an additional 38 are on order. As of November 1992, according to Lloyds' Green List, 98 double-hulled oil tankers ranging between 6,000 and 300,000 DWT were on order worldwide.

The first two double-hulled VLCCs have already been delivered, the first the ODENSE LINDO from Odense shipyard in Denmark, and the second the AROSA in January of this year from Hitachi Zosen in Japan.

I have no data on the number of single-hulled oil tankers ordered worldwide since OPA 1990. I believe it is a relatively low number. There have been no "mid-deck" oil tankers ordered as of this writing.

OPA 1990 as a Stimulus to U.S. Tanker Construction

At this writing, three years have passed since OPA 1990 created a world market for double-hulled tankers. Yet, despite worldwide construction thereof (see below), there have been no construction starts in the U.S. This would confirm that the U.S. commercial shipbuilding industry as we have known in the past few decades is more than moribund. It is dead. This is not all bad, as suggested by independent naval architect William duBarry Thomas in a paper entitled, "A New Business Ethic for U.S. Yards" [33].

At least three advanced double-hulled ship designs have been or are being developed which contemplate construction in U.S. facilities. They are:

- The ECO, Inc., design of a 40,000 DWT tanker for U.S. service
- The MarC Guardian proprietary design using standard cellular subassemblies for tankers from 40,000 – 320,000 DWT, U.S.-flag tankers and a comprehensive manufacturing plan therefor.
- The KVAERNER-MASA Marine Design which a joint venture of Ole Skaarup and McDermott Corporation (U.S. Shipbuilding Corporation) proposes to build in modular fashion.

There are undoubtedly other designs under development under the auspices of other shipbuilders.

The ECO, Inc., Design

ECO, Inc., of Annapolis, Maryland, has design a 40,000 DWT double-hulled tanker for U.S. service incorporating the design concepts of the late Joseph D. Porricelli. (Porricelli was one of the authors of the 1973 paper reporting the landmark industry/interagency study of 1972, which confirmed the merits of double-hull and double-bottom tankers for effecting pollution abatement [27].)

The ECO design is the first U.S. design to have been completed taking advantage of the American Bureau of Shipping's "Dynamic Loading Approach" [26]. Its ship-girder strength (resistance to sagging) is 60 percent greater than an equivalent single-hull tanker. It is designed for long life, employs mild steel throughout the hull, uses mill standard plates for hull construction, and incorporates advanced technology for the mitigation of corrosion, including the inerting of ballast tanks. Preliminary cost estimates for the ships are but 4.5 percent higher than the equivalent single-hulled tankers.

The MarC Guardian Program

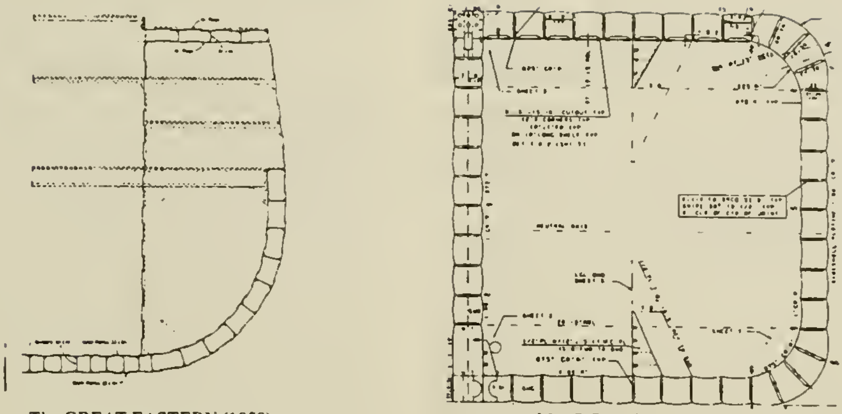
The proprietary MarC Guardian design and its associated manufacturing processes have been under intensive company-funded development since 1990 by the Metro Machine Corporation of Norfolk, Virginia, in concert with Marinex International of New York. Its basis is the highly automated serial manufacture of double-hulled tanker midbodies of longitudinal cellular construction using standard, mill run 8′ × 60′ mild steel plates. (See Figure 13, page 41.) Advantage is taken of a curved-panel concept invented and patented by Edmund G. Tornay. In 1992, based on Navy interest in the design for possible application to naval ships, the Metro Machine program attracted ARPA funding to match its own.

Standard 50-ft. longitudinal curved panels are joined to transversally stiffened panels of like overall dimensions in vertical jigs by three-way welding using a Metro Machine development of Lincoln Electric's electrogas welding process. This single-pass welding procedure, now qualified by ABS for three-way welds, takes advantage of the high deposition rate to largely eliminate thermal contraction or expansion and distortion during welding. All other welds for structural joining are to be made by the patented "Transferred, Ionized Molten Energy" (TIME) process using Fronius (Austrian) equipment. The TIME process has several advantages, including very high deposition rates and the elimination of weld splatter.

An integral part of the manufacturing process is Metro Machine's proprietary noncontaminating blasting and painting system (CAPE). This system is also applicable to all other ship construction methods, as well as to the renewal of paint systems during overhaul and repairs.

The welded and coated panels are progressively joined to make cellular bottom, side shell, and deck assemblies. Then, along with a bulkhead assembly, they are assembled into 2,500-

Figure 13. Examples of cellular construction in double-hull ships



The GREAT EASTERN (1858) MarC Guardian (1993)

Note: The late DavidArnott cited the GREAT EASTERN as "an outstanding example of what could be accomplished with a scientific approach to the design of double-hull ships " He further notes that the designer, Isambard Brunel, was one of the first to apply the beam theory to ship structural design [36]

ion modules which are, in turn, fully outfitted. The modules are launched and floated into position at an assembly drydock, rotated into vertical position, translated to join the previously erected modules in the dock, and welded thereto. The completed midbody is then joined in the dock to the completely outfitted bow and stern to finish the ship

The completed ship combines environmentally responsible features, operational cost advantages, and what could be the lowest construction costs yet achieved anywhere in the world Some of these features are

- Twin screw propulsion (using U.S.-manufactured slow-speed diesels) to enhance avoidance of collisions and groundings
- Long-life, high-performance coatings optimally applied
- Ease of inspection and maintenance of ship's structure
- High energy absorption by hull in event of grounding
- Cargo tanks one-half size of normal
- Hydrostatic balance capability in event of tank rupture.
- All fuel oil stored within the inner hull.

Besides Metro Machine and Marinex, active and prospective participants include:

- Ingalls Shipbuilding Division, Pascagoula, Mississippi (completely outfitted bow and stern propulsion and cargo modules).
- Westinghouse Corporation, New Orleans, Louisiana (22,000 HP slow-speed diesels).
- Bethlehem Steel Corporation, Sparrows Point, Maryland (milled steel plates).
- A broad spectrum of marine component suppliers.

Metro Machine will use its existing plant for the manufacture and preoutfitting of deck centerline and pipe tunnel assemblies Double-hull longitudinal assemblies will be manufactured and assembled into midbody modules at the former Sun Shipbuilding site in Chester, Pennsylvania A Charleston, South Carolina, facility will manufacture bulkheads and cargo midbody transition assemblies All completed modules and final assemblies will be integrated into the completed ships on VLCC launching pontoons at the Norfolk site. The initial planned production rate is the equivalent of four VLCCs per year It can be doubled to include production of a mix of smaller vessels

U.S. Shipbuilding Corporation Program

At this writing no details are available on this program, except that USSC, as in the Metro Machine design, is using unidirectional, longitudinal structure build-up from standard flat plates

Implementation

Implementation of these tanker construction programs will be discussed under "The Present and Future U S Shipbuilding Picture "

Leadership

It goes almost without saying that the success or failure of an enterprise large or small, global in scope or more restricted, depends on the qualities and vision of the people at the top. This has certainly been true in the shipbuilding cases mentioned in this paper.

The moral and ethical values in an organization start at the top This also applies to the work ethic. Owen G. Young of General Electric defined the high price of leadership as being the "burning of midnight oil" while others slept. This is certainly true in GE, and has been true in every successful shipbuilding effort with which I have been associated or have observed at close range. In turn, the diligence of the rank and file of any organization is very much determined by the consistent application of diligence at the top.

Professional pride in accomplishment, patriotism (in time of crisis), and financial incentive properly conceived and administered can contribute in varying degrees to motivating all levels of both supervision and the work force to work, harmoniously and unselfishly, to their highest level of capability

One powerful weapon is to keep all levels informed of the aims, goals, and accomplishments (including financial) of the organization as a whole. Evenhandedness from top to bottom in applying ethical standards and work rules is also essential Employee participation in ownership is another appropriate and powerful incentive

The same precepts apply with respect to the role of government in shipbuilding We have seen how in WWII entrepreneurial effort responded to the leadership of ADMs Land and Cochrane. We have seen how government leadership in the shipbuilding field has waxed, waned, waxed, and waned again in the 50 years since the start of WWII.

The members of this society are individually and collectively a vital part of the shipbuilding leadership matrix. The society has throughout its history taken a consistent and vital role in the development of budding naval architects, marine engineers, and shipbuilders The U.S. Coast Guard and the American Bureau of Shipping as regulatory and rule-making bodies have unremitting and vital responsibilities and leadership roles. Congress demonstrated its responsibility and leadership with respect to the environment with OPA 1990. We have noted the private initiatives already substantially demonstrated stemming from OPA 1990 – exemplified by Metro Machine's admirable development program. Sadly missing from the matrix at this critical juncture are the White House and the Maritime Administration (MARAD).

The Present and Future U.S. Shipbuilding Picture

Naval Shipbuilding

Substantial advances in the U.S. state of the art for naval ship design and construction, ship overhauls, and the management thereof have been achieved The principles and practices for effective management of the development, design, and construction process necessary for complex naval ships and their integrated systems have been proven in practice and documented, but not always applied consistently One hopes fundamental principles and practices have been sufficiently well defined and illuminated in our industry's data banks so that future generations of ship procurers and builders – despite changes in nomenclature and passing fads – will generate a minimum of "wheel reinvention and spinning" when and if programs requiring the building of extremely complex ships in short order have to be executed

The author is not qualified to even guess as to the mix of naval combatant and auxiliary ships that will be required in the future or how that will affect private shipyards. Certainly there will be fewer for a while as a function of the cessation of the cold war and the lessons learned in the Gulf War. Certainly there should be a lull as new precepts are being developed and translated into concrete plans.

The next year or two would seem to be an ideal time for the Navy to put its house in order organizationally and procedure-wise, and from top to bottom. In my opinion, an excellent first step was made in 1991 by the NAVSEA study initiated by RAdm Roger B. Horne, "Strategic Plan for Improving the Ship Design, Acquisition, and Construction Process" [6]. I assume this has been ongoing and in substantive fashion since that time. The effort and scope should be broad, and should be intensified if required A major goal should be organizational simplicity and clarity. Responsibility for ship contract plans and specifications should be clearly placed in NAVSEA or equivalent and not diffused. The organization should have the technical "firepower" to discharge its responsibility without undue farm-out to contractors and also to responsibly appraise that which they do farm out. In searching for a model, the WWII Bureau of Ships organization plan should be reexamined Remember the pre-WWII lessons of top-heavy destroyers which finally forced the consolidation of the Bureau of Engineering and the Bureau of Construction and Repair into the Bureau of Ships! The BuShips organization worked marvelously well through WWII and the "golden age" of submarine development, at least.

In general, and to use a current business buzzword, the entire Navy procurement, paperwork, and decision making process should be "re-engineered" to take out unnecessary layers and redundancy and to improve communications. (See "Special Report – The Technology Payoff," Business Week, June 14, 1993 [34].) If re-engineering can dramatically reduce span time from concept to commercialization in industry, it should be possible to reduce overall span times from concept to combat readiness on naval vessels back to those of the POLARIS era. The approach is essentially an old-fashioned, organized analysis of paperwork, procedures, and approvals including the mediums used When unessential fiefdoms are identified they should be eliminated It would also be extremely beneficial for a specially trained and qualified team to revise the Armed Services Procurement regulations and MIL specifications to ensure that they are written in plain and compelling English, and reduced in size. (See John Noga's observations on page 16.) The team's basic text should be *The Elements of Style* [35]. The team should also review and edit what should be a new organization manual on a "concurrent" basis.

Top management of private shipyards building naval ships will have to be selected not only for their textbook management skills, but most of all for their proven knowledge of the shipbuilding business.

Commercial Shipbuilding

> "Humpty Dumpty sat on e wall
> Humpty Dumpty hed a great fall
> All the king's horses end ell the king's men
> Couldn't put Humpty Dumpty togethar egain."
> – Ancient Rhyme

The slate is now clean with respect to commercial shipbuilding in this country. There is none. Nevertheless, there are, as we have discussed, strong private initiatives which give promise of not needing construction cost differential subsidies if a combination of national policy and some form of government and private financing can be devised, backed up by suitable guarantees, including, most importantly, guarantees of heads-up performance by the entrepreneurs who propose to build the ships – in this case, double-hulled tankers.

U.S. Maritime Policy

We have mentioned the sporadic White House interest in American shipbuilding and U.S.-flag shipping over the past 50 years. (Or, more correctly, 217 years, since the establishment of the republic in 1776!) I remember being callously told by a key White House official in 1970, with respect to pending layoff of 7,000 or so Quincy workers, that the White House could not possibly care less about them; this despite the fact that Nixon later signed the Merchant Marine Act of 1970. President Clinton was elected in large part on the basis of "jobs – jobs – jobs!" We have yet to see how, if at all, this pledge will help the shipbuilding industry, which, as history reminds us, is a solid

way to create worthwhile jobs, nor have we heard any declaration of strategic or national policy interest in U.S. shipbuilding and U.S.-flag shipping.

The U.S. Maritime Administration (MARAD)

The present status of MARAD is utterly deplorable. The agency's functions were originally included within the U.S. Maritime Commission, MARCOM, established in 1936, which reported directly to President Roosevelt. They were to be very shortly organized and developed by the late VAdm Emory S. Land, USN (Ret.). VAdm Land is our society's shipbuilding *icon*. As summarized in this paper, and dealt with in depth in Lane [4], MARCOM was *the* driving force in commercial ship design, shipbuilding, and U.S.-flag shipping through the end of WWII. For nearly three decades thereafter it was a major force. Now it is worse than dead – a mere custodial agency misfiled somewhere in the Department of Transportation. But some say the cost differential operating and construction subsidies it paid out helped the U.S. shipyards to grow lax and self-destruct, along with nearly all of the U.S.-flag fleets. They sincerely think that the idea of a U.S.-flag fleet is long since past, and that it should be allowed to die along with MARAD.

Nevertheless, as originally conceived and as organized under ADM Land, it is exactly the government agency needed to execute National Maritime Policy if there were even a chance of National Maritime Policy on the horizon – whether this includes reviving subsidies or not!

Nature abhors a vacuum, and the vacuum represented by the ghost of MARAD past has begun to be filled in an interesting manner by a combination of the Advanced Research Projects Agency (ARPA) and Congress.

The National Shipbuilding Initiative

The National Shipbuilding Initiative is, as of this writing, still a concept under consideration in Congress. It could be a major factor in the revival of a sound American shipbuilding industry, and competitive in world markets without subsidy, lead to the resurrection of U.S.-flag merchant shipping, and equally important, create productive, well paid job opportunities on an ongoing basis.

Its immediate precursor is the Defense Reinvestment Act, which is aimed at jump-starting a nondefense U.S. technological and manufacturing base to at least offset the decline in technological employment in the defense industry as the defense budget declines. The act provides for the distribution to defense contractors in 12 areas of $600 million based on solicited proposals to be submitted in July 1993. Shipbuilding is one of the areas to be funded. The lead government agency is the Advanced Research Projects Agency (ARPA).

Of interest is the fact that a precursor to the Defense Reinvestment Act was stimulated by the Navy's interest in certain of the MarC Guardian design features for application to naval auxiliary vessels. As previously noted, this resulted in the 1992 investment of (D)ARPA funds, through the Cardarock Division of the Navy Surface Warfare Center (CDNSWC), in the MarC Guardian R&D program, matching the then significant Metro Machine investment therein, for the development of the unique and progressive manufacturing processes required.

Public Law 102-482, October 23, 1992

Subtitle D of this law, "Defense Maritime Logistical Readiness," calls for an interagency working group for the "sole purpose of developing and implementing a comprehensive plan to enable and ensure that domestic shipyards can compete effectively in international shipbuilding."

It was directed that this be established not later than March 1, 1993, and that it include representatives from all appropriate agencies: the DOD, the State, Commerce, Transportation, and Labor Departments, the U.S. Trade Representative, and, by gosh, MARAD. It actually met for the first time in late May. What it will accomplish remains to be seen.

The White House Council on Sustainable Development

The writer would strongly recommend that the newly formed White House Council on Sustainable Development include in its considerations the U.S. shipbuilding/U.S.-flag shipping problem, and perhaps formulate and recommend how to best encourage U.S. shipbuilding and the solid jobs which it would generate if reincarnated. The White House could then decide whether to revive MARAD and the terms of its charter. They might do well to recruit representation from the National Security Council to participate.

Various Viewpoints

Lester Rosenblatt, naval architect and past president of the Society, put forth his individual views with respect to the future of U.S. commercial shipbuilding and U.S.-flag shipping in a November 14, 1992, speech at the State University of New York at Fort Schuyler [38]. He makes a strong case for a large U.S.-built and operated merchant fleet, and emphasizes that only the President of the U.S. can make it happen. This statement is certainly true if history is a guide. He identifies as a major hurdle to a U.S.-flag fleet without subsidies the differential in manning costs – U.S. and foreign. In summary he says:

> "We should as a nation within the parameters of marginally less managed trade and marginally more managed trade maneuver to create without the subsidies of yore regulatory/legal/economic conditions to make it possible for U.S. shipbuilding and shipbuilding to exist and even be profitable."

Captain Warren Leback last fall, while still administrator of MARAD, recommended that the best way to create several thousand worthwhile jobs quickly and efficiently would be to invest $500 million in 35 percent construction differential subsidies for double-hulled product carriers of 30,000 – 40,000 DWT. He felt that such a program, properly managed, could finance the production of 20 product carriers per year for a number of years. Spread among five existing yards, it could be implemented very quickly. He pointed out that an ever-increasing amount of our total oil imports are refined products (currently ±50 percent), as opposed to crude.

Captain Andrew Gibson, former MARAD administrator, has expressed the view that it is too late to revive commercial shipbuilding in the U.S., except for a diminishing number of Jones Act ships, and that we will soon see the remaining U.S.-flag fleets go to foreign flags.

My personal view is that the United States needs a viable industrial base which includes heavy industry such as shipbuilding. The U.S. also needs an economically viable U.S.-flag shipping fleet. I am confident that knowledgeable, heads-up management, adequately financed, can produce double-hulled ships starting with product carriers and/or crude carriers, and earn a respectable long-term return on investment. I think, based on my own experience with the LNGs, that little if any construction subsidy would be required. If shipyard managements are entrepreneurial and develop market savvy and even begin to approach their potential efficiency, they can more than compete in the world markets for double-hulled ships, which

we in the U.S. understand how best to produce. It will be a challenging task, and no one should approach it without being willing to pay the high price of leadership being eternally vigilant, progressive, and always looking at least 10 years ahead. I say – go to it! Get a shipbuilding renaissance underway. Identify and respect the hazards, but get moving.

One group of hazards is related to the environmental dangers we all face. One of them is discussed below.

Major Hurdles and Hazards

Financing

Perhaps the major hurdle to be overcome in achieving the realization of most private initiatives with respect to the resuscitation of U.S. shipbuilding is the financing of the development, the facilities, tooling, and initial production to the point of positive cash flow. Smaller enterprises that have little capital but the agility to move fast are stymied by lack of funding and the extreme disinterest of so-called "venture capital." Large organizations that have the financial resources are impeded by their sheer size and ingrained inertia that is not always in the right direction. The Economic Development Corporation is no longer in existence. There really is no such thing as private venture capital anymore. The Export-Import Bank finances production of planes and locomotives for foreign export – but not ships! The government financed the bail-out of the Chrysler Corporation a few years ago, and did not get hurt. Does the government care enough about a revival of commercial shipbuilding and the jobs it would generate to at least contribute the guarantees necessary for the private financing of its renaissance?

Note: All of the above notwithstanding, the shipyards *will* require superb, dedicated, and unrelentingly vigilant management to achieve a positive cash flow.

Global Warming

Global warming and world population growth are but two of the major interrelated external factors – both in the environmental classification – which shipbuilding management and maritime planners should include in their business planning networks or models. Both of these problems are now completely out of control and running amuck. Real programs with teeth in them must be instituted by world governments to solve these problems. I discuss here but one of them – global warming. Actions will have to be drastic and to tight, short-term schedules to solve them. These steps logically will require reduction in the emissions of CO_2. The U.S. is the biggest per capita culprit by far. Effective abatement steps will reduce present conventionally-arrived-at forecasts of oil imports into the U.S. This will, in turn, affect ship marketing and production programs.

At the Rio Conference last year, more than 150 nations signed the Convention on Climate, in which they agreed to stabilize the atmospheric composition at levels that would not cause climatic change of ecological significance. Stabilization, according to the scientific community, would require approximately 50 percent reduction from 1990 levels in emissions from use of fossil fuels. No nation has moved to make such a reduction. The U.S. has agreed to stabilize its own emissions at 1990 levels by the year 2000. Such a step is constructive, but far from what is required to stabilize the composition of the atmosphere.

The transportation sector (including ships, by the way), and automobiles in particular, is the largest producer of CO_2. To effect the necessary reductions in the use of gasoline, oil imports will have to be drastically reduced over the next seven years as a function of government regulatory actions. This will weaken the potential market for oil tankers.

If no effective *world* action (which has to be led by the U.S.) is taken, and greenhouse gases are not stabilized, we could face a significant environmental disaster within the same time period. The shock will affect oil imports in unpredictable ways. (Simulation modeling may be useful here!)

There is also an ancillary problem. It is coastal flooding as ocean temperatures rise in these latitudes as a function of unrestrained global warming. When and how do we plan to put shipyards on stilts?

I hope anyone who feels inclined to discuss this major problem will first have read and absorbed Vice President Al Gore's 1992 book, *Earth in the Balance* [37].

ACKNOWLEDGMENTS

My former shipbuilding colleagues Douglas C. McMillan, Alan Donkin, John L. Randall, John Noga, Arthur C. Taddei, Jack Dallinger, Henry Marcus, Richard Salzer, and Frank McConnell have reviewed this manuscript at one or another stages of its development, made important contributes, or endeavored to keep my own recollections as close to the mark as they could while along the way contributing to the proofreading thereof. I most sincerely thank them. In the same vein I am most grateful to Paul E. Atkinson, Daniel D. Strohmeier, Virgil F. Keith, Barry Thomas, Richard D. Thorpe, Jr., Charles Zeien, Merville Willis, RAdm Roger Horne, USN (Ret.), Richard E. Forrest, NAVSEA, and the staff of the Shipbuilders Council of America. Richard A. Goldbach generously shared his draft copy of his program for the future U.S.-construction of large U.S.-flag tankers. Errors of omission or commission are mine.

I particularly thank Doug Wilcox of WordSmith in South Weymouth, Mass., who stayed the course and converted my series of hand-written drafts and changes into a finished manuscript.

Most of all, and wherever you are, I thank the hundreds and indeed thousands with whom I worked over the years to build ships, and who in the course of doing so, helped mightily to advance the state of the art in this most demanding of all businesses. A few of you, but all too few, are mentioned in this paper. I particularly cite the wonderful planning staff that supported me at Electric Boat in the '50s and early '60s, the legions of skilled craftsmen in all the shipyards where I worked over the decades who were masters of their craft, and clear-thinking union officials. When management did their part and prepared the way, you shipbuilders performed miracles. I also thank the knowledgeable and invaluable partners that we in the shipyards had in the Navy officers and staff of BuShips, SupShips, and the PCOs (Prospective Commanding Officers), and the Board of Inspection and Survey – all of whom were dedicated to achieving common goals with us shipbuilders. The same is true of vendors and subcontractors, and, on the commercial side, of owners, representatives, and ABS personnel.

I have not discussed several important aspects of shipbuilding management which I felt were adequately dealt with in the literature. However, among this paper's deficiencies is its failure to adequately cover the procurement, subcontracting, and inventory management process. Lindsay A. Fowler was responsible for bringing Electric Boat operations in these areas up to par and a great deal further in the '50s, including the safeguards (epitomized by his own absolute rectitude) against fraud and kickbacks – essential when there is so much tempting cash flow. He later did the same for American Shipbuilding and Ingalls.

I had hoped to discuss management systems at Bath, Avondale, NASSCO, and Newport News, but will have to leave that to others. Also, the Great Lakes yards deserved attention, as well as yards along the waterways and smaller salt water yards. Not the least of the latter is Luther Blount's wonderful, no-nonsense yard in Warren, Rhode Island, built from scratch with Yankee ingenuity over the decades we speak of, and entirely financed from its earnings even to this day!

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9-21-93 - verbal approval to Carl Bretzel

Paper No. 7

SHIPBUILDING AND SHIPBUILDING MANAGEMENT, 1943-1993

Oral Presentation

by Lloyd Bergeson

for delivery at

The Society of Naval Architects and Marine Engineers
Centennial Meeting

September 16, 1993

The dominating aspect of shipbuilding during the last 50 years has been a repeat of the feast and famine cycles which had prevailed since Civil War days. Many wonderful ships were conceived, engineered, and built during the period, but construction of ocean-going commercial ships finally expired several years ago, as shown in Figure T-1, even as U.S. technical leadership in shipbuilding peaked. U.S.-flag shipping is on the verge of extinction, destroyed by excesses in labor costs and the continued subsidization thereof. Whether commercial shipbuilding will be revived is an open question. Naval shipbuilding will be sharply curtailed. **T-1**

It is of historical interest that the industrial strength which made the splendid World War II shipbuilding record possible can be traced directly to its source--Colonial shipbuilding in New England. Shipbuilding and the resultant shipping industry started in the early seventeenth century. That early shipbuilding effort was made by the colonists out of pure necessity--do or die. Only by building vessels could the fisheries and abundant timber be exploited by trading the harvest with Europe and England for tools and other necessities for the colonists. Both shipbuilding and shipping all along the coast was a matter of many individual private initiatives of heroic nature. It had to be done for survival, despite royal strictures against Colonial shipbuilding and shipping, and it was. From it, over a handful of decades, grew the great shipping, mercantile, and

> banking enterprises of individual families headed initially and invariably by the more successful of the early shipbuilding/shipping entrepreneurs. It was the profits earned from shipping that financed the successful war of revolution against the British, and subsequently the industrial revolution in the United States. The Puritan/Quaker work ethic and moral standards and individual integrity were also a major factor in the success of the Colonial shipbuilding and shipping miracle. But it would not have been possible, had the colonists not been able to exploit seemingly inexhaustible resources in virgin territory. The colonists' practice of "free enterprise" underlay, at least in part, the development of the free enterprise theory as published by Adam Smith in The Wealth of Nations in 1776.

It would be nice to think that by polishing up the old Yankee virtues (a work ethic, high moral standards, and individual integrity) and applying them in a spirit of free enterprise as we know it, we could revive a shipbuilding industry utilizing our unsurpassed know-how. The ABS is taking the lead worldwide in providing design tools and rules for producing new ships which will provide the greatest degree of safety of "life, property, and the environment." But conditions have changed, and it will not be all that easy. Continental natural resources have been importantly exploited. Technology has enabled larger ships which economics of size dictate. The larger ships may not be more complex, but new facilities and tooling to take advantage of new processes will be needed, and substantial financing will be required. Continental natural resources have been importantly exploited. It is already apparent that operating subsidies will not be continued in any form, nor will construction differential cost subsidies. The time advantage that a going industry could have enjoyed in the market for double-hulled tankers created by OPA '90 has been importantly eroded. As of this writing

(9/7/93), it is an open question whether Title XI guarantees will be available even in connection with the financing of shipbuilding facilities. Vice President Gore's National Policy Review was released September 7, taking the position that Congress should deregulate the U.S. maritime industry.

I suggested in my paper that the size and timing of the future market for ships of all kinds (including double-hulled tankers) was inextricably linked to world population, global warming, and their associated problems. I believe shipping patterns and requirements for other types of ships will be similarly affected by what is done or not done relative to overriding external factors. I think achieving a stabilized environment is orders of magnitude more important to the solving of the future of U.S. shipbuilding than resolving the current diametrically opposed views of the administration and Congress, important though that is.

A stable environment is the major prerequisite to successful entrepreneurial planning of any kind, including shipbuilding. Therefore, I want to enlarge a bit on the subject of population growth and global warming, as mentioned in the paper.

First, Uncontrolled Population Growth. The whole future of **T-2**
life, commerce, and industry on this planet is linked to this phenomenon. But mankind is literally incapable of limiting uncontrolled growth--all attempts to do so by reason or edict have failed. Thus, the horror picture before you. The many aspects of overpopulation, including its environmental effects, are global, grim, and tragic to most of those thus placed on this

earth at the present rate of 250,000 per day, or 100 million per year. It is heart-rending to all but the most callous of observers. The problem is to some degree, as in Somalia, regulated by food supplies or lack thereof--starvation. An ancillary problem here is exponential loss of species other than man. T-3

Global Warming, or anthropogenic (man-made) climate change, is the second overriding external force. But something can be done and must be done to contain this conflagration and restore a state of environmental equilibrium--action is long overdue. I believe the Society of Naval Architects and Marine Engineers can and must contribute to the solution, both individually and collectively--whether through altruism or enlightened self-interest.

Man-generated CO_2 in the troposphere is the principal, but not the only, element or "forcing" component resulting in the "Greenhouse Effect" and the resultant accelerating global warming, complete with lethal side effects which by now should be apparent to even the most sheltered of persons living in air-conditioned enclaves [7, 9]. I will not go into the mechanism of it here.

CO_2 has been discernibly building up in the troposphere, we now know, since the industrial revolution began to accelerate. It is very much a function of it, in particular through the proliferation of the internal combustion engine. Consistent, accurate measurements of CO_2 build-up were begun in 1958 in the Mauna Laua, Hawaii, observatory under the direction of Charles

David Keeling. The data are one of the most remarkable sets of geochemical measurements of the earth ever made, and clearly show the accumulation of CO_2 in the atmosphere. The increase is now about 30 percent above the CO_2 content in the latter half of the last century.

Global average temperature rise has been consistently measured since 1880, and scientists have watched an accelerated warming. This warming from 1890 to 1990 has been about 0.6° Celsius. But the rate of warming has been about 0.3° in the last decade. This level of rise may seem benign, but it is not. In the Arctic it is up to seven times the rise occurring at the equator, and in these latitudes it is three to four times the rise at the equator.* The rates of rise of CO_2 and temperature are similar, but CO_2 rise has led the temperature rise on the time scale. Recent core borings in Antarctica have shown this relationship over the past 160,000 years [8]. **T-4** **T-5**

The advent of high-powered computers made the modeling of sources and sinks for carbon in the atmosphere and the quantifications thereof possible. Much of this early research and modeling was done by military and other government scientists, as well as by Government-financed research projects in various universities and laboratories, as it still is.

> In one branch of the research which should particularly interest this body, it was hypothesized that the reality and rate of temperature rise in the Arctic (which is up to seven times higher than the global average rate), could be measured by core borings in the ice cover over the Arctic Sea. This task was undertaken by the U.S. Air Force under

*In the McKenzie Basin of northwestern Canada, it is more than seven times the rise for the earth as a whole!

the direction of the late, great COL Bernt Balchan early in the 1960s. In 1968, systematic profiling by SONAR of the underside of the ice was started using the first nuclear submarine, NAUTILUS. The military was not concerned with Global Warming as such, but the military ramifications of the thinning ice pack and surface and submerged operations in relation thereto. Unfortunately, this data which would have been and still would be invaluable to climatologists was labeled SECRET. Shamefully, only a tiny fraction of it has been ~~related~~ released to date. Two readings ten years apart by British scientists show thinning of 15 percent [3, 4].

By the late 1970s, climatologists around the world had extensively modeled the sources and effect of CO_2 and other greenhouse gases, and the capacity of the world's oceans, dwindling forests, and other "sinks' to absorb the anthropogenic greenhouse gases and those natural greenhouse gases generated in the relatively stable environment that existed for the 200,000 years which preceded the industrial revolution. It became obvious that their capacity had become overwhelmed. Also, the temperature rise and many of the ancillary and unpleasant side effects could be modeled in relation to the basic equations governing the state of climate equilibrium that had until this century prevailed for that 200,000-year period. The picture was not pretty [5, 9]. The range of predictions of ΔT from various models and scenarios is shown on T-6.* Some of these ancillary **T-6**
effects are now all too readily apparent to a large percentage of the globe's population, and our own insular society, even though the public at large may not yet link them to the cause--global warming. A few are:

- Diminished thickness of the Arctic sea ice cover (some say 15 percent in a recent ten-year period [1, 8]

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*Referring back to T-6, the top line is the worst case--no effective action; the bottom line represents immediate action applied now--even this is scary as hell.

- Stalled weather fronts and attendant catastrophic droughts and deluges [1, 8] T-7

- Greater frequency and intensity of storms and hurricanes

- Prolonged calms and decreases in the reliability of trade winds

- Sea level rise and coastal flooding due to expansion (measurements complicated by local tipping of the continental shelf)

- Dramatically increased frequency (from 5 to 50 percent by 2050) of drought as continental centers dry out [6]

Most important, it became recognized that CO_2 buildup, unlike that of CFCs, was cumulative and irreversible on a time scale of less than hundreds of years. Thus, even when remedial measures are taken, we will never reattain the equilibrium conditions that had prevailed for 200,000 years, and up to the early part of this century. If we took immediate action the achieved equilibrium conditions would, when achieved, still be exponentially worse for viable life on this planet. But that is what we must shoot for in the hope that things will stabilize at a tolerable level. It will take extraordinary effort, as discussed later. If we take no action, further delay it, or do less than is necesary (which we have since 1979!), we risk severe, progressive biotic impoverishment of the earth as a whole, and that means people and every other organism.

This realization came to concerned scientists in the late '70s. George M. Woodwell, now Director of the Woods Hole Research Center, was asked to provide a report to the President's Council on Environmental Quality on the ramifications of global warming. His report, cosigned by three other leading scientists, Gordon J. MacDonald, Roger Revelle, and C. David Keeling, was

concise, comprehensive, and sobering. The situation and the need for action was reviewed by the scientists with President Carter, and widely reported in the press and scientific journals. The report was the first clear warning of disaster ahead if prompt action was not taken to reduce CO_2 emissions [1]. Carter did nothing as such, but, as a function of the energy crisis highlighted by the OPEC-engineered explosion of crude oil prices in the late '60s, higher miles-per-gallon requirements were stipulated for automobiles. Had the auto industry been held to the goals on the required time scale, this would have gone far to reduce the rate of increase in CO_2 in the atmosphere. But Reagan and Bush negated that when they came to power, and for 12 critical years the U.S. government's official position was that there was not a global warming problem. This position became ludicrous in 1988, when in testimony to Congress the United States' leading climatologist, Dr. James E. Hansen, Director of NASA's Goddard Institute for Space Studies (GISS), bravely spoke out on this subject. He summarized the results of temperature measurement research carried out to that date:

- The Earth is presently (1988) warmer than at any time in the history of instrumental measurements (starting in 1880)
- The greenhouse effect is probably the principal cause of global warming
- The greenhouse effect is already large enough to begin to affect the probability of extreme events such as summer heat waves

He further noted that:

- Warming in the twenty-five years up to 1988 was the highest in the 100-year period of record

- 1988 would be the warmest on record (which is was to that date)
- The five warmest years counting 1988 all occurred in the 1980s, and that at least by 1995 the "man in the street" would have noticed the change and called for an explanation [To many of us it has long since been apparent!]
- There was strong evidence that the increase in greenhouse gases would cause a significant increase in heat wave/drought situations in mid-latitude continental regions such as the U.S. (and it has).

He concluded that global warming was fact, not theory [2].

His statements were right on the button. For the first time since the Woodwell paper, global warming received national media attention, and on the wider scale it deserved. President Bush, annoyed at these facts and their exposure, cut Hansen's budget drastically, and stoutly denied the existence of a global warming problem to the end of his regime.

Subsequent events have confirmed Hansen's statements in spades, as illustrated by GISS's plot of global mean temperature changes [V6, 7], 1990 being the warmest year on record, 1991 being another record high year, despite a half a year of the cooling effect of the mid-1989 Mt. Pinatubo eruption which introduced temporary stratospheric cooling aerosols. Climate models showed that this would continue to have a damping effect on global mean temperatures in 1992 and 1993, after which global temperatures would continue to set records [10, 11]. In 1992 global mean temperatures were, in fact, depressed as the GISS model predicted.

I noted in the paper that the marine industry's planning models should take these global factors into account as best they

could, in order to assure the least-worst market forecasts. In the meantime, things environmental are indeed markedly worse than they were in 1979 and in 1988. Much of the responsibility for lack of adequate action lies squarely with the politicians, and to some degree, with those scientists who are hesitant to say there is sufficient scientific proof because, even with the realities staring them in the face, their models cannot exactly replicate or correlate with actual occurrences. They want time and money to fine tune their models and develop more data points, but this will not change the facts. Unfortunately, it gives the politicians a golden excuse for continued inaction--an inaction that cannot be tolerated by the biota affected--all humans, including politicians. But we must rely on the politicians because they are the only ones who can cut the directive necessary. Even the details of the grossly inadequate remedial plan announced earlier this year by the Clinton White House--for rolling back CO_2 emissions to 1990 levels by the year 2000--scheduled to be announced on August 14, now has been indefinitely postponed, according to recent press reports.

I have noted the practical difficulty of creating a climate for investment in shipbuilding facilities and tooling (even for exported ships) in the face of such uncertainty. A basic prerequisite to eliminating the uncertainty is to restabilize the environment. The Society of Naval Architects and Marine Engineers, is a responsible body of engineers of high integrity used to solving complex and massive problems. I believe we must, as a step toward our own survival and as a matter of enlightened

self-interest, form up as a constituency not for recreating the pork barrel, but for mitigating and stabilizing this terrible threat to life on earth--global warming. The 9,500 members of this Society speaking as one voice might even be heard in government circles as clearly as the American Petroleum Institute has been heard in the past. We are told by social scientists that humans are genetically incapable of altruism. I do not believe it, but we certainly know that this is true of corporations. Action-based, enlightened self-interest must be the basic motivation. We cannot allow the alternative to happen.

Further, the shipbuilding industry is uniquely qualified to contribute in a planning and management mode to the complex matrix of subsets to the problem which must be solved.

That which only government can do must be urged on by a constituency for action to which we can contribute importantly. The action I have in mind is to employ Vice President Gore's idea of a global environmental Marshall Plan but on a crash basis, and do it, if necessary, on the scale of the World War II shipbuilding program, with at least the intellectual input of the WWII Manhattan (nuclear bomb) Project, but with the disciplined planning and execution as demonstrated by the POLARIS FBM Program and as described in my paper.*

I personally feel that basic elements of the global warming fix already identified by scores of research projects and studies

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**Note:* Albert Gore in his book [13] covers the whole range of environmental problems that must be solved. In these remarks I focus only on what I think is by far the most critical--<u>global warming</u>.

could be triggered by a few strokes of the pen in the form of Presidential directives. More precisely planned actions can come later--like the next day! The best organized, current, and comprehensive work confirming the need for an immediate reduction of CO_2 emissions and outlining the fixes which will have to be made, starting with automobile emissions, first and foremost is contained in the 1990 volume entitled Climate Change, and its follow-up volume, Climate Change 1992. This is the work of the World Meteorological [UN] Organization's Intergovernmental Panel on Climate Change (IPCC) [ ], involving several hundreds of top scientists around the world. It impressively backs up the 1979 report of Woodwell and the 1988 testimony of Hansen. IPCC calculated that CO2 and other long-lived gases from human activities require reductions of over 60% to stabilize their concentrations at today's levels. Methane requires a 15 to 20 percent reduction. The actions have to be scoped, planned, and engineered; assignments made and acted upon; further research of course, but only as a function of fine tuning model inputs. The automobile industry will have to stop moaning and groaning, even as it continues to romanticize over-engined automobiles, It must face up to its responsibility for mitigating the damage to which it has with full knowledge contributed (at least since 1979) leading towards global disaster. It is a rich challenge and full of opportunity. Those in denial are literally contributing to mankind's demise.

With the environment stabilized, we can then sort out trade opportunities and find shipbuilding and shipping niches which we

can and should fill. I have suggested, based on my own experience with the LNGs in the early '70s, that they could have and should have been competitive worldwide without subsidy. I think they could now if we tooled up. The same is true of the U.S. oil tanker designs being developed. Because of ship size, either heavy-hitting investors must change their ways from the pursuant of the fast buck and come into the picture, or Government must provide loan guarantees for facilities and other start-up costs; maybe a combination of both.

Ship propulsion can be made more environmentally friendly through further fuel economies. Wind propulsion in the form of sail-assist devices added to oceangoing ships operating below 14 knots (or the knuckle in the speed/power curve) were proved with the full-scale MINI-LACE experiement of the early '80s and the coordinated research program.* MINI-LACE achieved a 24 percent reduction in fuel consumption in tramping, plus a 6 percent increas in transit speed, and a 40 percent reduction on selected trade routes [15, 16]. When and as world shipping develops healthy cash flow, sail-assist rigs should be considered for initial installation or as retrofits.

> The Wind Ship analytical model and hardware designs and studies are available for reference. They are at MIT in the custody of Professor Chrys Chrssostomidis, the Hart Nautical Collection, and the mind of Professor Henry Marcus, one of Wind Ship's cofounders.

Shipyard managements will have to be willing to pay the high price of leadership. They will have to know their business and be unrelenting in the pursuit of manufacturing excellence. They

* George P Livanos of Carras Shipping, owner of MINI-LACE underwrote the engineering, construction + rigorous test in service of this eminently successful Sail-Assist rig.

will have to really work at marketing proprietary products, not wait for bid opportunities.

In the external factors department, there must, in society as a whole, be a "Moral Re-Armament" (akin to the "Buchmanism" espoused by Harry Truman to the defense industry at the start of World War II). We have seen what happens when free enterprise runs amok without moral or ethical restraint and is deficient in intellectual integrity and diligence in planning and solving business problems. There are rich rewards, but no easy bucks to be made, in honest shipbuilding.

In the shipyards, environmental considerations and efforts will have to be both local and contributing to effective global actions. Action to fix the former will pay off short term, the latter <u>must</u> pay off or we all--saints and sinners alike--will be cooked.

New leaders must rise from our ranks with the integrity, savvy, desire, and will to succeed in the most noble and satisfying of all businesses, shipbuilding.

Note: Copies of the above remarks, illustrations, and references are available from the author.

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To Accompany Oral Presentation

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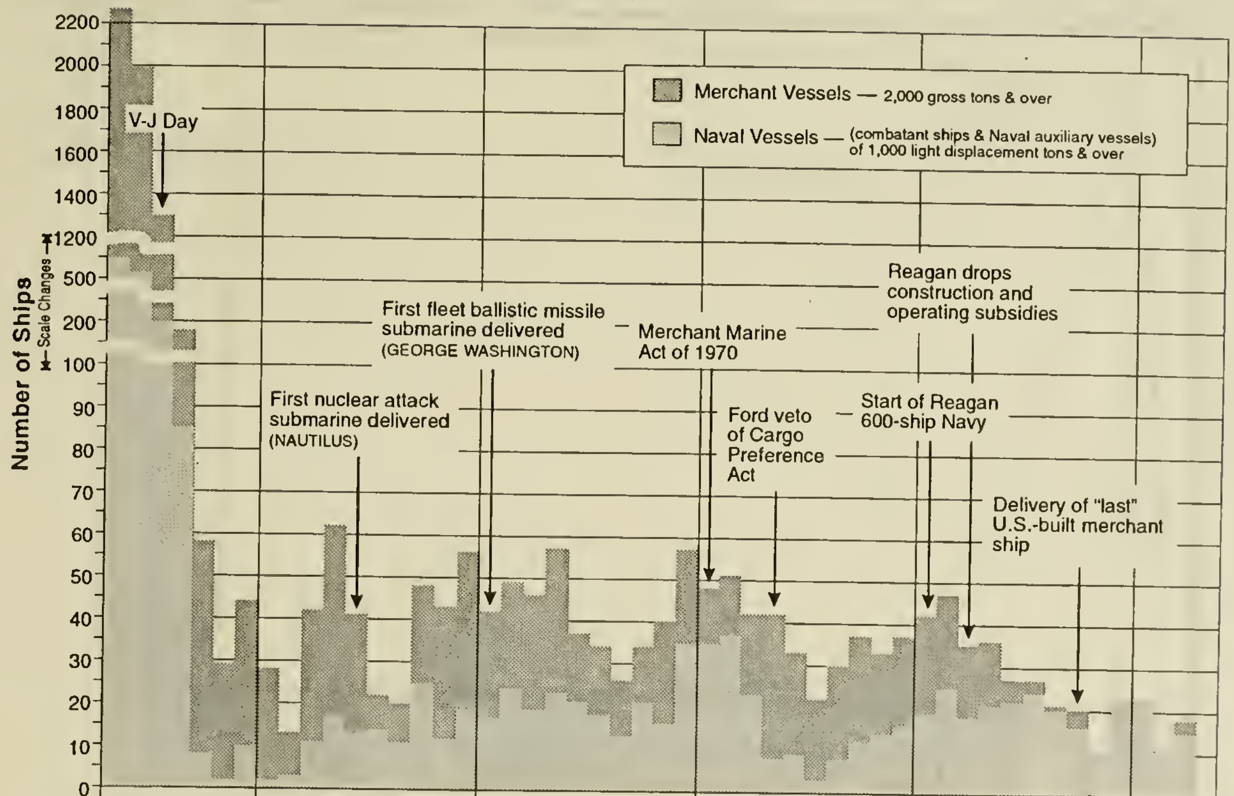
Verbal Presentation

Shipbuilding and Shipbuilding Management, 1943-1993

Illustrations

T-1

50 Years of U.S. Ship Construction
1943-1993



Year (1940s)	'43	'44	'45	'46	'47	'48	'49
Merchant	1661	1463	1067	87	50	27	34
Naval	608	535	203	85	6	2	10
Total	2269	1998	1270	172	50	29	44

Year (1950s)	'50	'51	'52	'53	'54	'55	'56	'57	'58	'59
Merchant	26	10	31	45	38	8	0	23	31	32
Naval	2	3	11	17	13	14	11	25	12	19
Total	28	13	42	62	51	22	20	48	43	51

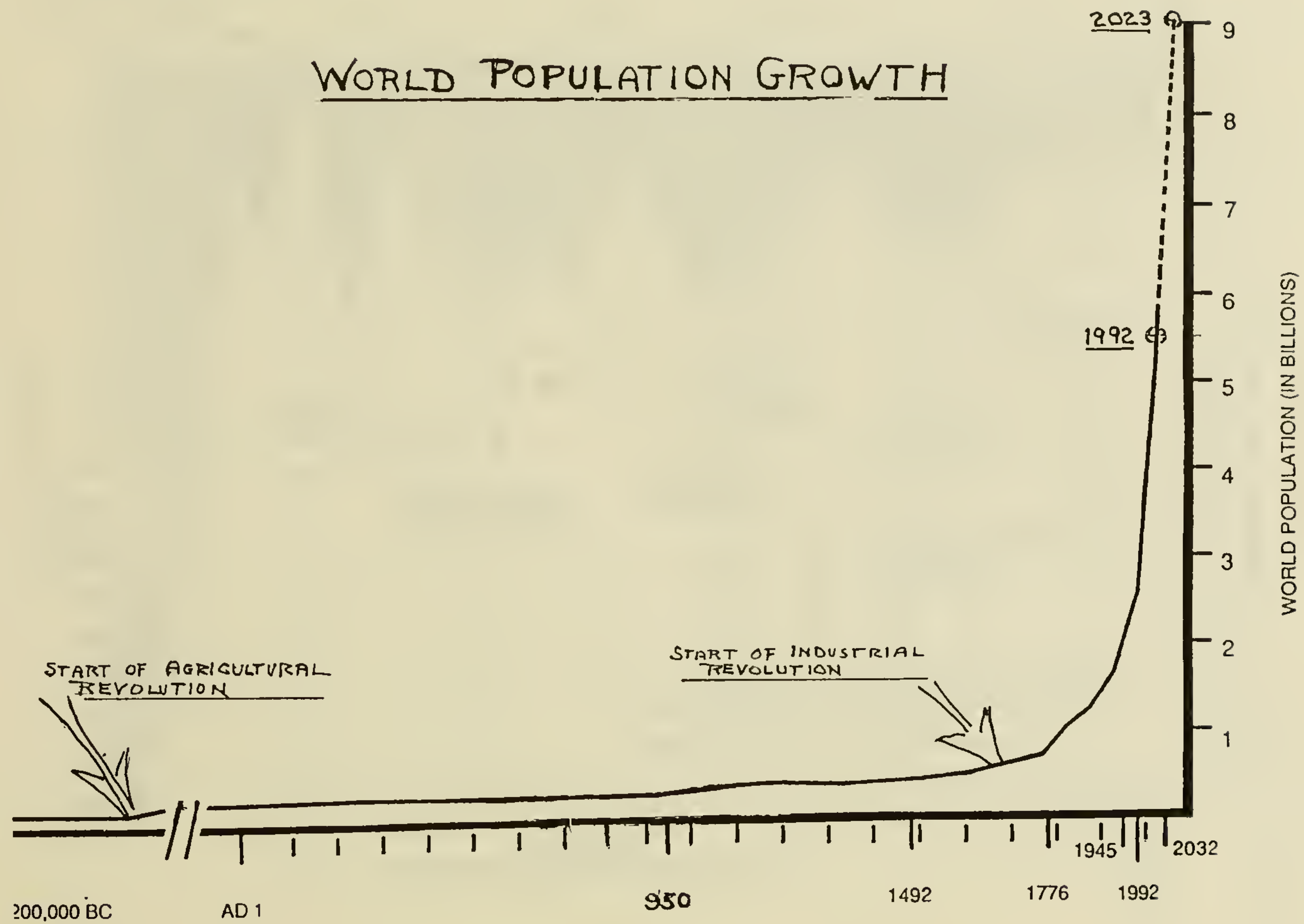
Year (1960s)	'60	'61	'62	'63	'64	'65	'66	'67	'68	'69
Merchant	25	25	27	34	16	16	13	13	24	22
Naval	17	24	19	23	21	16	13	21	16	35
Total	42	49	46	57	37	34	26	34	40	57

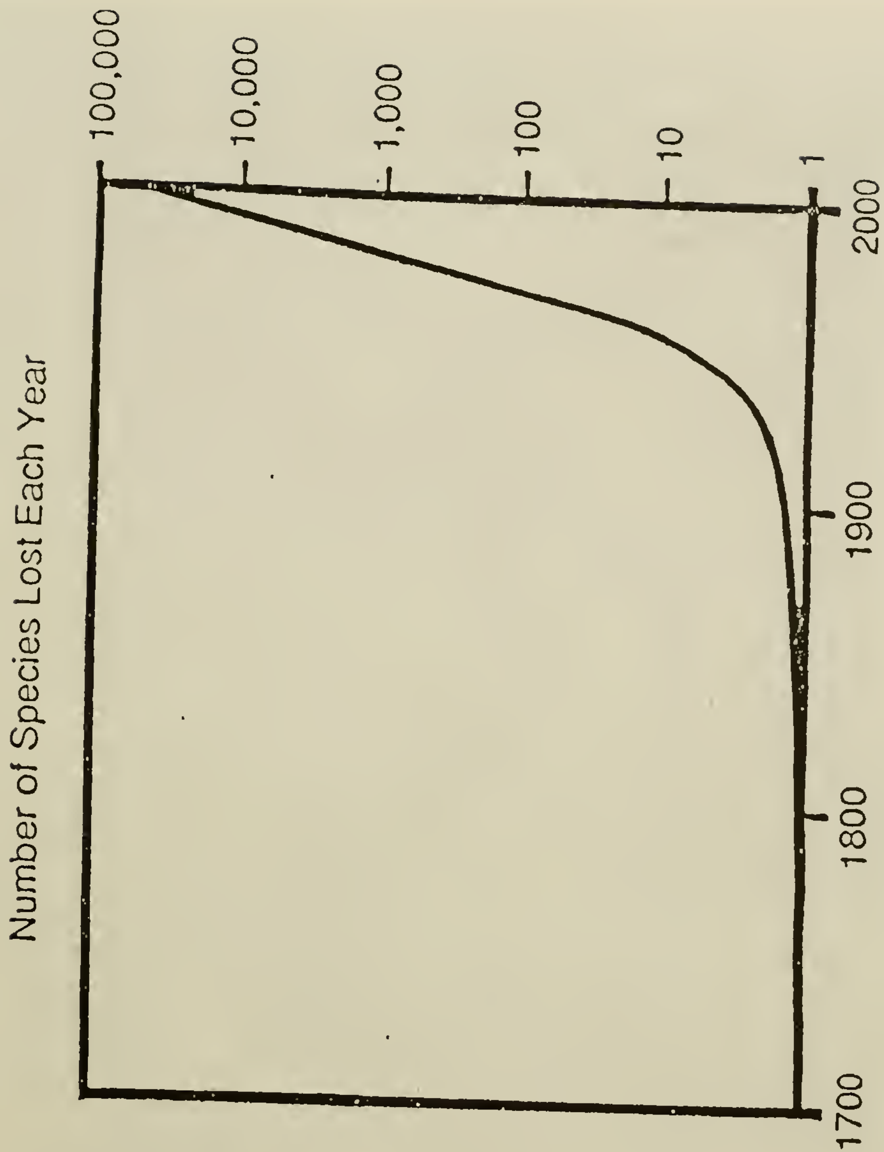
Year (1970s)	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79
Merchant	13	14	19	34	24	19	22	25	19	21
Naval	35	37	23	8	9	3	8	12	14	16
Total	48	51	42	42	33	22	30	37	33	37

Year (1980s)	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89
Merchant	23	22	17	15	5	3	1	4	0	0
Naval	19	25	18	21	22	24	20	16	10	23
Total	42	47	35	36	27	27	21	20	10	23

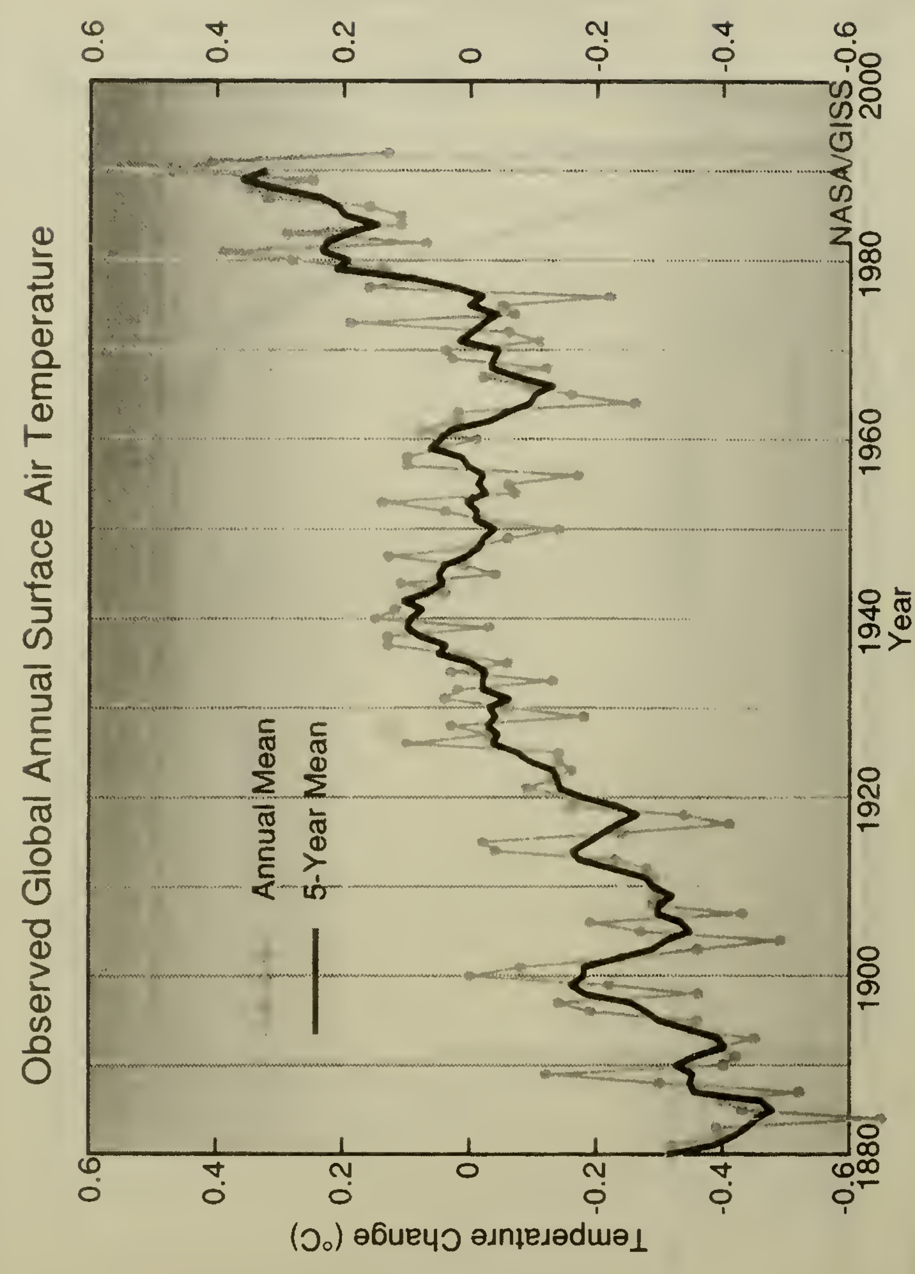
Year (1990s)	'90	'91	'92	'93
Merchant	0	0	3	
Naval	23	11	15	
Total	23	11	18	

Source: Shipbuilders' Council of America


WORLD POPULATION GROWTH
WORLD POPULATION (IN BILLIONS)
1
2
3
4
5
6
7
8
9
2023
1992
START OF AGRICULTURAL REVOLUTION
START OF INDUSTRIAL REVOLUTION
200,000 BC
AD 1
950
1492
1776
1945
1992
2032

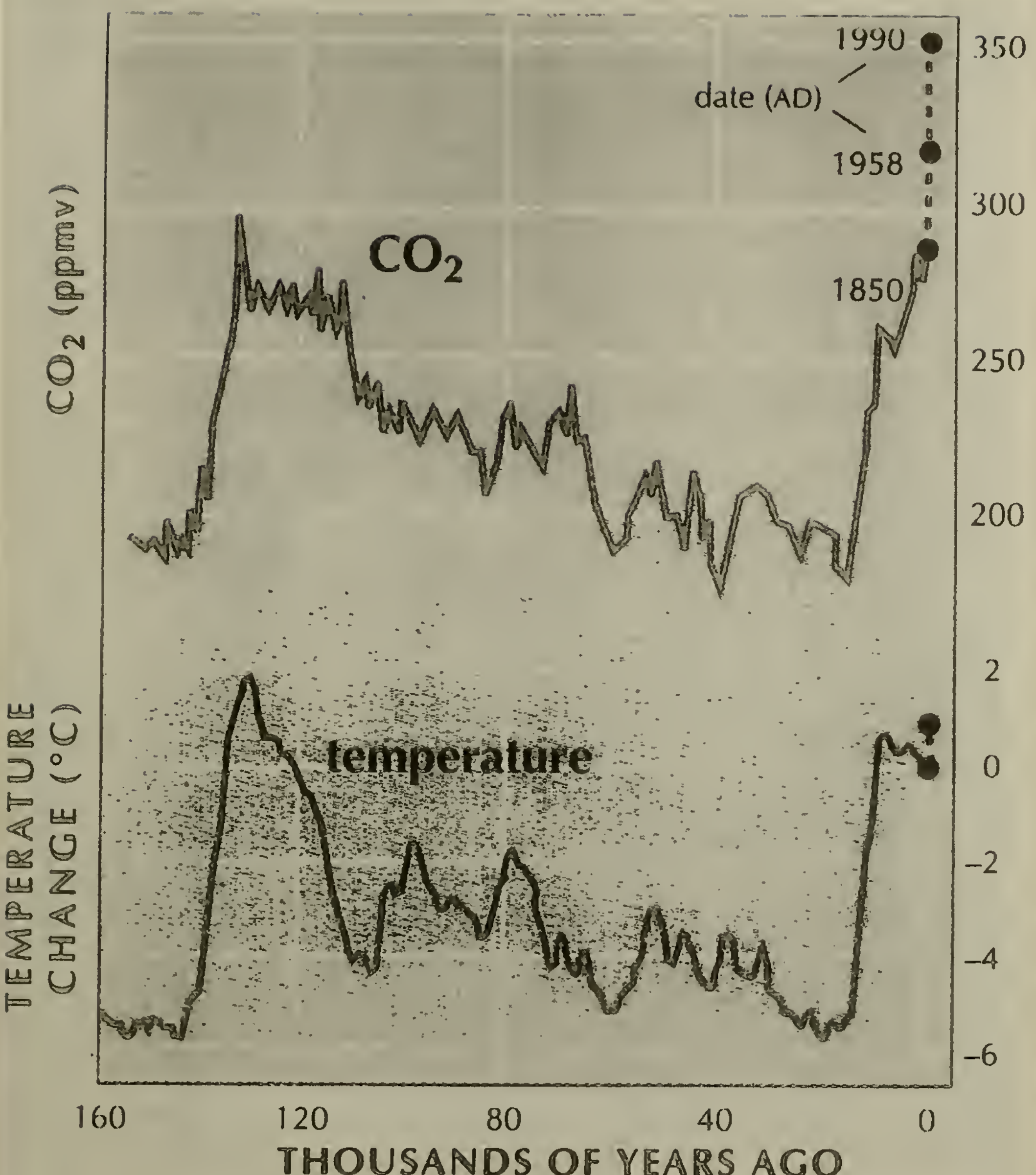

Number of Species Lost Each Year
100,000
10,000
1,000
100
10
1
2000
1900
1800
1700

I-4



Source: NASA - Goddard Institute for Space Studies

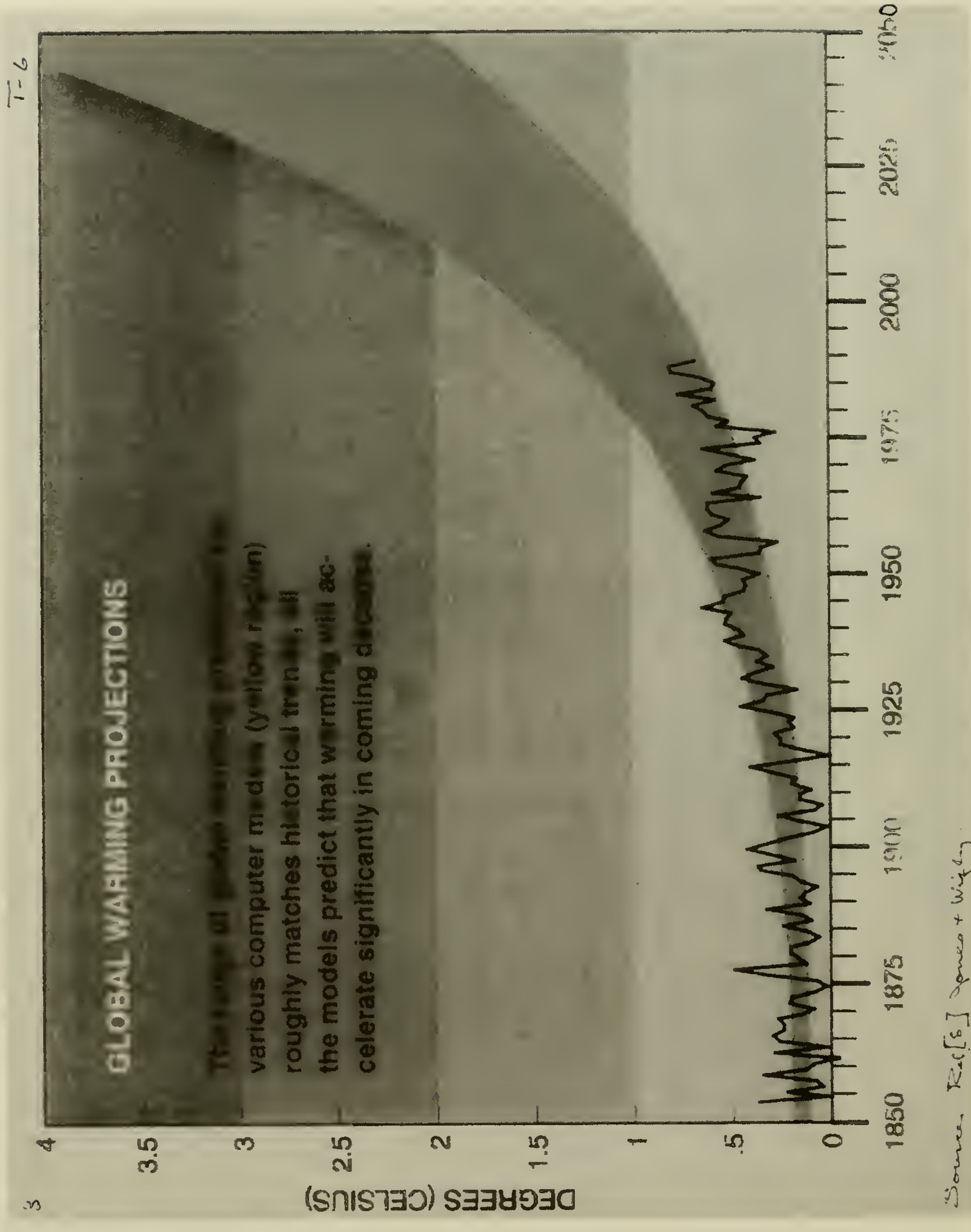
T-5



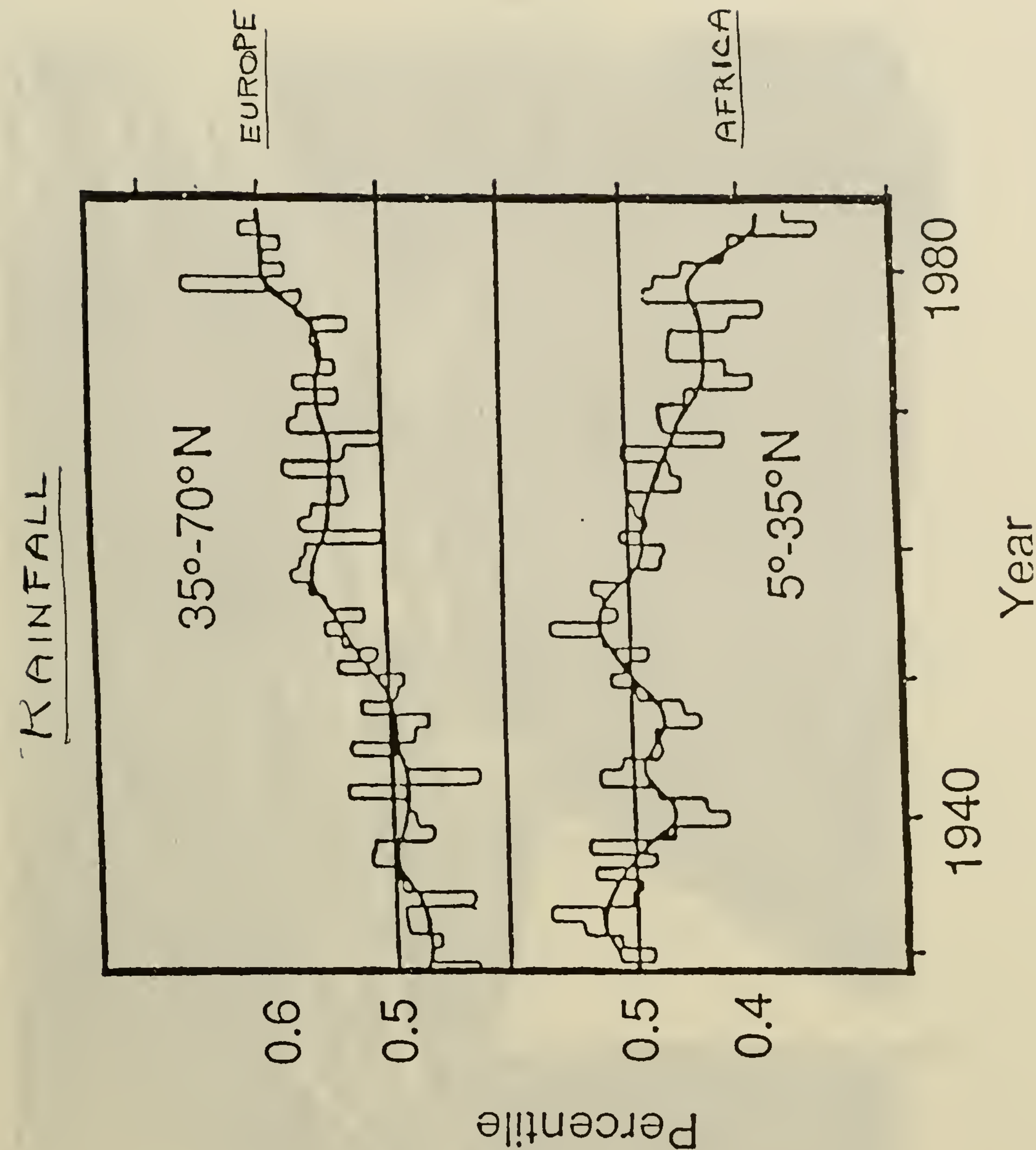
CO_2 and temperature records from Antarctic ice cores over the past 160 000 years, and recent atmospheric measurements.

Source: Ref [8] Hansen et al. "Climate Sensitivity"

T-6

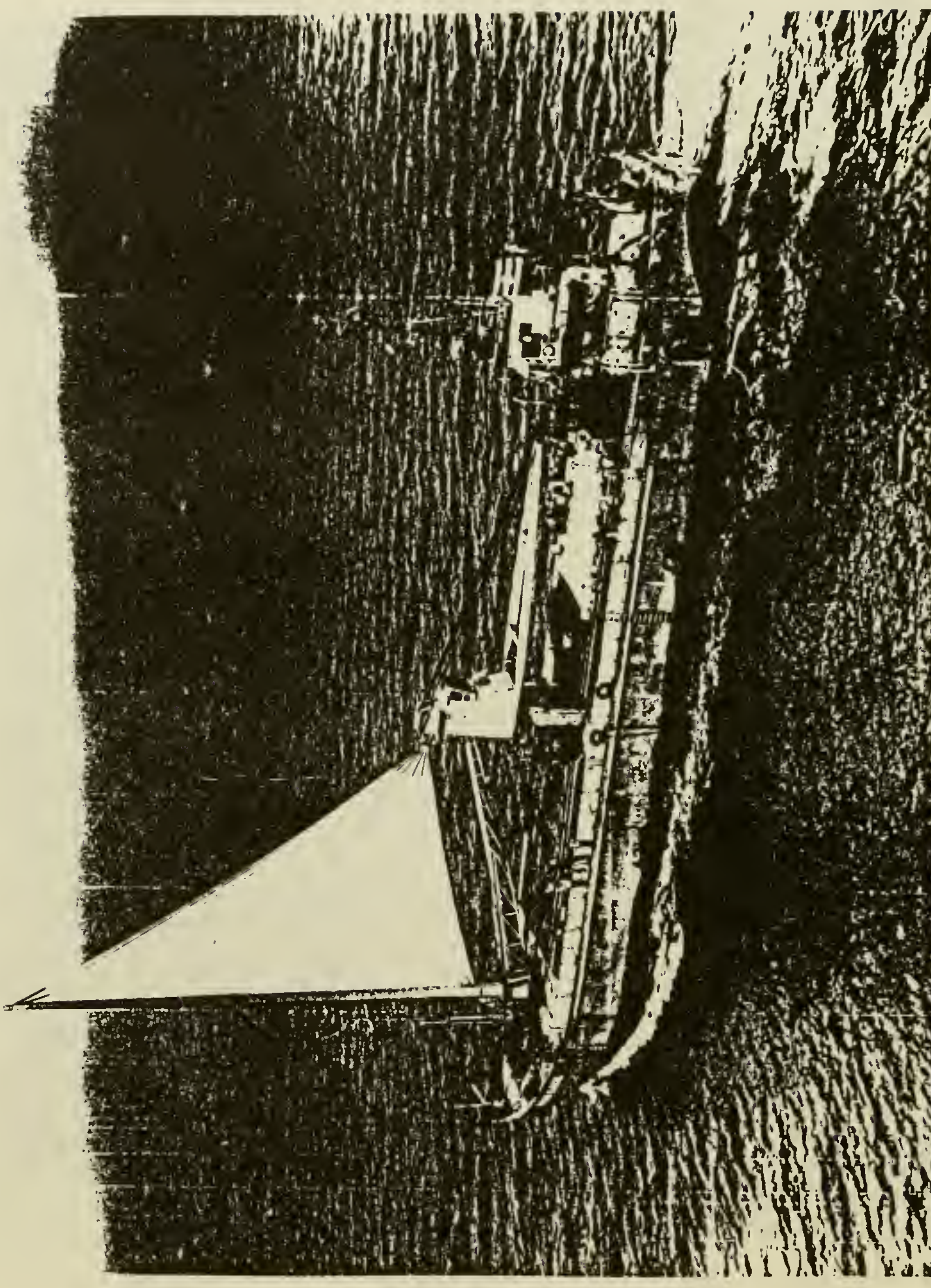


Source: Ref[5] Jones + Wigley


RAINFALL
EUROPE
AFRICA
35°-70°N
5°-35°N
1940
1980
Year
0.6
0.5
0.5
0.4
Percentile

T-8

T-8



Mini Lace - Sail-Assist Rig   Sea Trials 8/25/81   3000 DWT/3000 ft² Sail Area

Lloyd Bergeson

Lloyd Bergeson has been general manager of two major shipyards--the Quincy Shipbuilding Division of General Dynamics Corp., and the Ingalls Shipbuilding Corporation. Earlier, he directed the planning and production, material, and cost engineering (estimating) activities of General dynamics' Electric Boat Division during the development of land-based, prototype nuclear power plants and the world's first eight seagoing nuclear submarine prototypes. He coordinated all Electric Boat activities in the development, design, and construction of the first POLARIS missile submarine, the U.S.S. GEORGE WASHINGTON. At Quincy, he was responsible for developing and marketing the world's first 125,000-cubic-meter liquefied natural gas (LNG) tankers. He has planned or directed the engineering design and construction of 20 different classes of major commercial and naval ships. During World War II he directed planning and production control activities at Cramp Shipbuilding Corp., Philadelphia, Pennsylvania.

In addition, he has provided consulting and management services for several shipyards, the U.S. Atomic Energy Commission, and for a wide variety of commercial development projects, including solid state and cryogenic devices and equipment, jet engines, chemical process plants, and 1,000-megawatt nuclear power plants.

A lifelong yachtsman, he has cruised and raced extensively over the last 50 years, and in 1978 made a single-handed passage under sail from North America to Norway. In the course of that voyage, he hypothesized that the world's shipping fleet could significantly help in cutting down on fossil fuel emissions by utilizing wind power in the form of sail-assist devices, and founded Wind Ship Development Corp. to facilitate its proof. It was proven at sea with the full-scale MINI-LACE experiment in 1980-1982, and the concurrent testing of wing sails and Flettner Rotors, and the computer aided modeling of possible fuel economies on a wide range of commercial ships on various trade routes.

He graduated from MIT in 1938 with a S.B. degree in naval architecture and marine engineering.

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